DAVY'S
EXPERIMENTAL GUIDE
TO
CHEMISTRY

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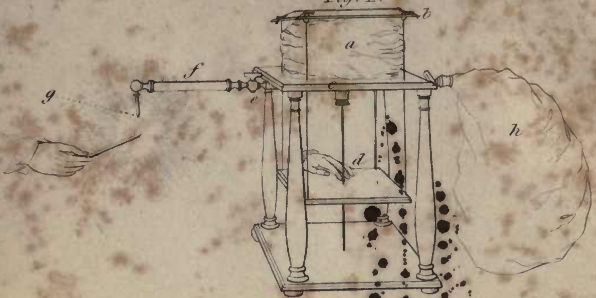
Oxyhydrogen Blowpipe.

Fig. 1.



Collection of Gases

see page 22.

Fig. 2.

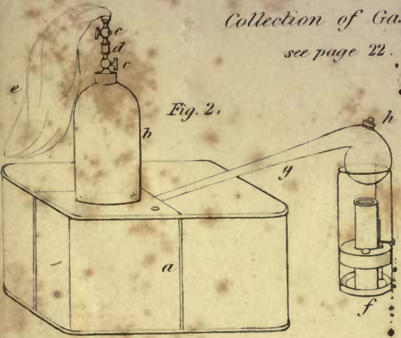
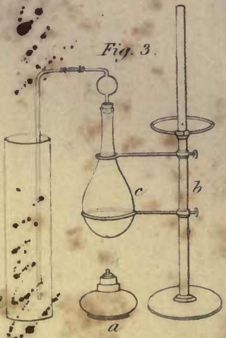
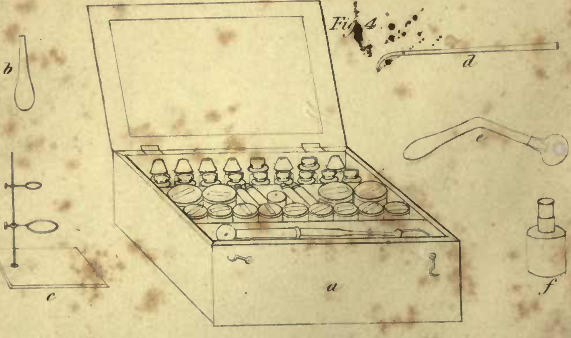


Fig. 3.



Chemical Chests.

Fig. 4.



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AN

EXPERIMENTAL GUIDE

TO

CHEMISTRY.

BY EDWARD DAVY,

MEMBER OF THE ROYAL COLLEGE OF SURGEONS.

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> Segnius irritant animos demissa per aures
> Quam quæ sunt oculis commissa fidelibus.
> HORACE ARS POETICA.

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PREFACE.

Chemistry owes almost its existence, as a science, to the discoveries of modern times. So little were its principles understood a few centuries ago, that it was in a great degree confounded with the black art; and there has been a time, when a person who could have exhibited some of the experiments described in this little volume, would have incurred much risk of perishing at the stake as a sorcerer.

The clouds of the dark ages have happily been dispelled; and the labours of a long succession of philosophers have gradually unfolded many of the hidden properties of matter. A science has thus been developed, not only peculiarly beautiful from the varied phenomena it presents, and interesting from the light it throws on nature's second causes; but also useful, in the highest degree, from its extensive application to the arts of life. Modern Chemistry has lent its aid to mechanical science, and enabled man to traverse the ocean against wind and tide; to glide over the earth's surface with immense loads, and with a speed surpassing that of the race-horse; and to ascend and progress for miles in the air in the car of a balloon. A great proportion of the manufactures are purely chemical; and the success of all attemps to improve them must depend on the correct application of scientific knowledge.

Since then there are numerous occupations in life where this knowledge is indispensable; and as a branch of general information, it possesses claims upon all intelligent persons; it is not surprising that it should become more and more studied every day, and that it should now be so much introduced into schools, where it answers most fully the double purpose of recreation and instruction. When Chemistry shall have its due rank assigned to it, as one of the most valuable branches of human knowledge, there cannot be a doubt that this will be still more universally the case.

In the present little work, the object of the author has been to make the subjects on which he has treated perfectly clear and intelligible; to furnish minute directions to such as are novices in chemical manipulation, the observance of which may tend to render their experiments more successful; and, on the whole, to comprise as much useful information as possible in the smallest space.

AN

EXPERIMENTAL GUIDE

TO

CHEMISTRY.

PART I.

A Series of Experiments calculated to initiate the Student in the various Operations of Practical Chemistry; with incidental Explanations of the Technical Terms of the Science, and the Rationale of the Phenomena that occur.

SOLUTION. PRODUCTION OF ARTIFICIAL COLD.

Experiment 1.—Let a phial be half filled with cold water: add to it by degrees muriate of ammonia in fine powder; shaking between each addition, until no more is dissolved. The clear liquid is then a *solution* of the muriate of ammonia; and if it contain as much of this salt as it can possibly take up, it is said to be *saturated.* In the present instance, a considerable degree of cold is produced, as the hand will discover; and a thermometer having its bulb immersed in the solution, would sink to near the freezing point. Many salts produce cold to a certain extent by solution in water, and some combinations of them have this effect to such a degree as to enable us to form ice, and even freeze mercury in summer time. These are called *freezing mixtures.* See *Experiment* 69.

INSOLUBILITY. PRECIPITATION.

Exp. 2.—Camphor is incapable of being dissolved by water in any appreciable quantity. It is said to be *insoluble* in that liquid: but it is readily dissolved by strong spirits of wine (alcohol). Common salt, on the other hand, though soluble in water, is insoluble in spirits of wine.

Exp. 3.—Put a little solution of common salt into a test tube; add rather more than an equal quantity of alcohol, and shake them together; the mixture will become thick, and on being allowed to stand, a powder will settle at the bottom. This is the salt, which was previously dissolved in the water, and it is now said to be *precipitated;* being insoluble, not only in alcohol, but in a mixture of that fluid with water. On the further addition of a large quantity of water, the salt will be re-dissolved.

Exp. 4.—Camphor may in like manner be precipitated from its solution in alcohol by the addition of water; only from its greater lightness, the precipitate will float at the surface. A precipitate may be separated from a liquid either by *subsidence* and *decantation*, or by *filtration*, for which see *Exp.* 20.

EVAPORATION.

Exp. 5.—Put a few tea-spoonfuls of a solution of salt, or common sea water, into an evaporating basin, or watch glass, and support it on the ring-stand. Apply the spirit lamp under it, observing to move the latter about gently, because if the heat were constantly applied to one part of the basin or glass, there would be a risk of cracking it. The water of the solution will soon begin to fly off in the form of vapour, and the salt will ultimately remain perfectly dry. It is said to be *evaporated* to *dryness*. The water is called a *volatile*, and the salt a *fixed* body.

Exp. 6.—Put a little of a similar solution into an evaporating basin, saucer, or any flat, shallow vessel, and expose it to the air, uncovered and undisturbed, in a place free from dust. The water will fly off by slow degrees, and is said to *evaporate spontaneously;* while the salt will be deposited in regular forms called *crystals*. In a few days or weeks, (according to the quantity of liquid exposed, the warmth and dryness of the air, the form of the vessel, the surface it exposes, &c.) nothing but the salt will remain behind. It is on this principle that salt is in some places prepared on a great scale by the spontaneous evaporation of sea water, exposed to the sun in large trenches dug in the earth.

SOLUBILITY INCREASED BY HEAT. CRYSTALIZATION.

Exp. 7.—Common salt is *almost equally* soluble in cold and in hot water: but with most substances this is not the case. Half fill a flask with cold water, and add nitrate of potass (in powder), until no more is dissolved. Then place the flask on the ring-stand, and apply the heat of the lamp (with the precautions given in *Exp.* 5), until the liquid boils. Add more nitrate of potass by degrees, when the water will dissolve three or four times as much as it did when cold. Pour off the clear solution while boiling hot into a basin, and let it remain undisturbed until cold, or until the next day. Three-fourths of the nitrate of potass will have separated from the solution, not as a shapeless mass, but in regular forms. It has *crystalized.*

Exp. 8.—Repeat the last experiment with different substances in succession, instead of the nitrate of potass. For instance, alum, boracic acid, sulphate of soda, sulphate of magnesia, sulphate of copper, sulphate of potass, &c. These substances will be found to possess very different degrees of solubility, and each will crystalize in a form peculiar to itself.

Exp. 9.—Dissolve an equal quantity of nitrate of potass and sub-carbonate of potass, in as much hot water as is just sufficient for the purpose. On cooling, a great portion of the former salt will crystalize, being less soluble than the sub-carbonate, which remains in solution. The solution, after separating the crystals, is called the *mother liquor;* and as it may still contain some nitrate of potass, evaporate it until a distinct crust or skin, called a *pellicle,* is formed on its surface; when, on cooling, a fresh crop of crystals will be obtained. By repeated evaporations after this manner, delicately managed, substances differing in solubility, may often be entirely separated from each other.

ACIDS. SIMPLE AND COMPOUND SUBSTANCES.

Acids have a sour taste, and the property of converting vegetable blues to red. They combine with alkalies, earths, and metallic oxides, forming a numerous class of compound bodies called *salts*. The acids themselves are numerous, and they are all compound bodies.

Sulphur is a *simple* or *elementary* body; that is, it is incapable of being separated into any two or more forms of matter possessing different qualities. Oxigen is also a simple body, differing much from sulphur in its properties. These two by combination may produce sulphuric acid; a substance so different from either, that the nature of its ingredients could not be guessed at from its external characters. Sulphuric acid is a *primary compound*, and when it is further combined with another substance, as with lime, it forms sulphate of lime, which is a *secondary compound.*

Exp. 10.—Into a wine glass or test tube pour a little tincture of red cabbage; then add a drop or two of sulphuric acid, distilled vinegar, or any other acid, and observe the change of colour from blue to red.

Exp. 11.—Put two or three drops of sulphuric acid into a glass of water: dip into it a slip of litmus paper, and observe the change of colour. Litmus paper is much employed as an evidence, or as it is called, a *test* of the presence of uncombined acid, which it will detect if even in a very small proportion.

ALKALINE SUBSTANCES.

The *alkalies* potass, soda, and ammonia, possess a peculiarly caustic, burning taste; and as well as the *alkaline earths*, baryta, strentia, and magnesia, which more or less resemble them in properties, have the property of converting vegetable blues to green, and the yellow colour of turmeric or rhubarb to a reddish brown.

Exp. 12.—Add lime water or sub-carbonate of potass, &c. to tincture of red cabbage, or infusion of red roses, and observe the change of colour from blue to green.

Exp. 13.—Moisten a slip of turmeric paper with a weak solution of ammonia; then dip it into distilled vinegar, which will re-produce the original yellow colour.

Exp. 14.—To tincture of cabbage add first alkali and then acid alternately, the colour will be as often changed from red to green, and from green to red. If to the liquid when red, the alkali be gradually added in exact proportion, a blue may be re-produced; but then a minute additional quantity of alkali will turn it green.

DILUTION. COMBINATION. NEUTRALIZATION, AND SATURATION.

Exp. 15.—Let a test tube be one-third filled with cold water; then add by little and little almost an equal bulk of strong sulphuric acid, shaking it gently. The mixture will become hotter than boiling water. Whenever there is occasion to form this mixture, which is called a *diluted* acid, in order to avoid cracking the glass vessel, the acid must be added in small portions at a time to the water (and not the water to the acid), waiting awhile between each addition.

Exp. 16.—To a solution of caustic potass (which unless considerably diluted, is too burning to be tasted), add diluted nitric acid in small quantity, and stir with a glass rod. Dip into it a slip of turmeric paper, and if this becomes reddish brown, add more acid carefully, drop by drop, again stirring until the paper is no longer reddened. Then try its effect on litmus paper which will be reddened, if too much acid has been employed, but not otherwise. In this case, add more potass, until the liquid affects the colour of neither the litmus nor the turmeric. It is then said to be *neutral*, and has ceased to possess either the taste, causticity, or any other property of either of the ingredients. The acid has *combined* with the potass, and is *saturated* with it; forming a *neutral salt*, nitrate of potass, which may be obtained by evaporating and crystalizing the solution, as in *Exp.* 7.

In every neutral salt, the substance combined with the acid, whether it be an alkaline earth, or the oxide of a metal, is called the *base*.

ATTRACTION. AFFINITY.

Substances capable of combining together, are said to have an *attraction*, or *affinity*, for each other; the latter is an incorrect term, but much in use.

Attraction is of three kinds; namely, ATTRACTION of GRAVITATION, ATTRACTION of COHESION, and CHEMICAL ATTRACTION.

1st.—*Attraction of Gravitation* exists between bodies not necessarily in contact, and at *unlimited distances.* Thus the sun attracts the earth; the earth attracts the moon, and all bodies near its surface, just as a magnet attracts iron. In this way *all bodies* are supposed mutually to attract each other.

2d.—*Attraction of Cohesion* is that which retains the particles of a body together with more or less force, and is the cause why a block of granite does not fall to powder. Hardness, ductility, flexibility, &c. depend on modifications of cohesive attraction, which does not exist except where the particles of a body are in apparent contact, or in one mass; in other words, *at insensible distances.* It is, strictly speaking, a property of solids only.

3d.—*Chemical Attraction* is that power which causes the particles of dissimilar bodies to combine, as in *Exp.* 16. It operates at insensible distances, and between particles inconceivably minute, whether of solids, liquids, or gases. One substance, A, may possess a more powerful force than another, B, for a third substance, C; and in this case, A may displace B from its combination with C, as in the following experiment:—

Exp. 17.—Put a few grains of copper wire into a flask with a little diluted nitric acid. A violent action resembling boiling will presently take place. This is called *effervescence*, and as it diminishes, a gentle heat must be applied. The copper will gradually dissolve, forming a beautiful blue solution. When the acid will take up no more, or is saturated, immerse a rod, or any other piece of clean polished iron into the solution. The iron, having a *stronger attraction* for the acid than the copper has, will separate the copper from its former combination. The copper will be precipitated in the form of a coating on the surface of the iron, while a corresponding portion of iron will take its place in the solution. As this gradually loses its blue colour, the nitrate of copper is here said to be *decomposed*, and we have an instance of *single decomposition*. The iron may afterwards be proved to exist in the solution, by adding a few drops of tincture of galls, which will produce a black colour. Vide *Exp*. 131.

Exp. 18.—Rub together in a mortar equal parts of caustic potass, or quicklime, and muriate of ammonia. The potass, having a stronger attraction for the acid, will drive off the ammonia in the form of a gas, which though invisible, possesses a very pungent smell.

Exp. 19.—Into a solution of nitrate of copper (*Exp*. 17) pour a solution of sub-carbonate of potass, until on the subsidence of the green precipitate which is formed, the liquid has become colourless. The acids and basis of the two original salts will have reciprocally changed places with one another; the precipitate being a *carbonate of copper*, while the solution contains *nitrate of potass*, which may be crystalized by evaporation. This is called *double decomposition*, and the following diagram is usually employed to illustrate it. The original compounds are at the top and bottom: the new products at the sides.

$$\begin{array}{c}
\text{Nitrate of copper.}\\
\overbrace{\hphantom{\text{Nitric acid.}\qquad\text{Oxide of copper.}}}\\
\text{composed of}\\
\text{Nitrate of potass.}\left\{\begin{array}{ll}\text{Nitric acid.} & \text{Oxide of copper.}\\ & \\ \text{Potass.} & \text{Carbonic acid.}\end{array}\right\}\text{Carbonate of copper.}\\
\underbrace{\hphantom{\text{Nitric acid.}\qquad\text{Oxide of copper.}}}\\
\text{Carbonate of potass.}
\end{array}$$

DECANTATION. FILTRATION. WASHING.

Exp. 20.—In order to separate the carbonate of copper, produced in the last experiment, from the solution of nitrate of potass we may proceed as follows. Allow the precipitate to settle, which is best done in a lipped ale-glass, or a precipitating glass. Then carefully pour off as much of the liquid as will run clear: this is called *decantation*. The glass may then be filled up with water, (in accurate experiments distilled water is employed,) again allowed to settle, and again poured off. This is repeated many times, until the soluble nitrate of potass is sufficiently washed away. But this is best effected by filtration, or straining, either through cloth, or in preference through unsized paper, which separates the insoluble powder from the liquid more effectually. A precipitate is generally separated far more easily, whether by subsidence or by filtration, if previously *boiled* for a few minutes in the liquid in which it is suspended. The heat appears to render it more compact. Boiling the precipitate, however, is not admissible in the present experiment, as it would alter its colour and composition.

Take a square piece of filtering paper, fold it from corner to corner in halves and quarters: then open it between two of the folds, and place it in a funnel, which has a bottle or glass under it. Pour the thick liquid into the filter gently and down the sides, to avoid breaking it. The clear liquid will gradually drop through the funnel leaving the precipitate in the filter. When it ceases to drop, some warm water must be poured into the filter, over the precipitate; this will cause it to drop afresh, and the water will gradually carry down the soluble salt. This is to be repeated until the liquid drops through tasteless, and a little of it evaporated to dryness in a watch glass, leaves no residue or stain. Until this be the case, the precipitate has not been washed enough. If, however, common water be employed, it will almost always leave a slight residue on evaporation.

We must not always trust to this simple mode of washing a precipitate, especially if it be bulky, and not easily permeated by fluids: the second time the water is added, the whole should be stirred with a blunt glass rod thoroughly, but cautiously, as there is a risk of breaking the filter. This should be repeated several times on subsequent additions of water.

The vessel into which the filtered liquor runs may be frequently changed, in order that, if the filter should happen to break, the whole may not have to be filtered again.

After the filter has drained for some time, it may, with its contents, be spread out in the open air with a cloth under it to dry at leisure; or the precipitate may be removed with or without its filter, and dried by a gentle heat in an evaporating basin, or in any other convenient way.

Some precipitates will not bear the application of much heat in drying them: still less will crystals.

DELIQUESCENCE. EFFLORESCENCE. WATER OF CRYSTALIZATION.

Exp. 21.—Expose a little muriate of lime, nitrate of copper, or sub-carbonate of potass to the air in a watch glass, or any open vessel. It will soon become moist, and by the next day will be quite liquid. This property is called *deliquescence*, and it is owing to the absorption of moisture which exists in the air in the dryest weather. All deliquescent substances require to be kept in bottles carefully stopped.

Exp. 22.—Select a few clear crystals of sulphate of soda, free from dust or white powder. Weigh them and note down the weight. Expose them to the air for many days, until they have lost their crystaline appearance, and become converted into a white powder. This powder will be found to weigh less than the original crystals. Salts that are liable to this change are said to be *efflorescent:* and it arises from their parting with a certain quantity of water existing in combination with the salt, but in no degree affecting its dryness to the touch. Most salts, but not all, contain water thus combined. Sulphate of soda is one that contains a large proportion: those which contain none are said to be *anhydrous*. Efflorescence occurs either when the quantity of water is excessive, or the force of the attraction by which it is held in combination weak. From nearly all salts the water of crystalization may be expelled by a moderate degree of heat.

GASES AND VAPOURS.

Gas is a form of matter, resembling air in its general properties, exceedingly light, elastic, transparent, and with few exceptions, invisible and colourless. It is capable of being condensed into a smaller space by pressure, on the removal of which, it instantly regains its former dimensions. Its particles have no cohesion whatever; on the contrary, they repel one another to an almost unlimited extent; for on removing the ordinary pressure, it will expand and completely occupy all the space it can find. A bubble may be made by this expansion to fill a hogshead.

A *vapour* may be said to be a temporary gas, and a *gas* a permanent vapour; the distinction being this:—a substance which is fluid or solid at the common temperature of the air, when rendered æriform by heat, is called a *vapour*:—and a substance which remains æriform, unless exposed to extraordinary pressure or extreme cold, is called a *gas*.

Exp. 23.—Boil water in a flask over the spirit lamp, until the steam or vapour issues freely from the neck. Observe that the steam is invisible as common air, until by mixing with the surrounding cold atmosphere, it has, in fact, ceased to be steam, and is condensed into minute particles of water.

DISTILLATION.

Exp. 24.—Into a common glass retort, or into the little tube retort in the chest, introduce as much rum as will one-third fill the body, or that part beyond the bend of the vessel. In doing this, carefully avoid wetting the neck of the retort, that none of the rum may afterwards contaminate the distilled liquid; with this view, pour the liquid in by means of a funnel, with a neck so long as to reach beyond the bend of the retort. Support the retort on the ring-stand, and insert its mouth into the neck of the receiver, so that the mouth of the retort shall just enter the body of the receiver. Let the receiver rest in an evaporating basin, or any convenient vessel, so that it may be nearly surrounded by cold water. Apply a gentle heat to the body of the retort. The rum will shortly boil: when the vapour will rise, and expelling the common air before it, pass over into the receiver, and become condensed into a colourless liquid, by the cold to which it is there exposed. When about half the rum has been thus *distilled*, examine the products by comparing the liquid remaining in the retort with that which has passed into the receiver. The former will have acquired a deeper colour, will have lost its pungent taste, and its inflammability; the latter will be colourless, very hot to the taste, and very inflammable. Ordinary rum, and proof spirits in general, consist of alcohol and water in nearly equal proportions, together with some *colouring matter*. The strong alcohol being more volatile, passes over first in distillation, and the colouring matter remains behind altogether. The re-distillation of a liquid to increase its strength or purity is called *rectification;* thus we have rectified spirits of wine. A common phial will serve as a receiver to the tube retort.

In distillation with the retort and receiver, unless the process is conducted very slowly, the application of cold to the receiver alone is not sufficient to condense the vapour completely as fast as it comes over. The neck of the retort may be surrounded by a piece of linen, and kept constantly wet, by supporting over it a funnel filled with water, which has its throat obstructed with tow, or a notched cork, so that the liquid can only pass through it by drops. A quilled receiver is sometimes convenient, as it not only increases the condensing surface, but also enables us, if desired, to remove a portion of the distilled product in the middle of the process without interrupting it. This kind of receiver has a long tube, called the quill, coming from the bottom of it, which is to be inserted into a large flask or bottle of thin glass. The bottle may be immersed up to its neck in cold water or ice if necessary, and must be fixed down to prevent its floating.

In the distillation of fluids which do not corrode metallic vessels, such as spirituous liquors, the refrigeration is effected by means of the worm tub.

Exp. 25.—Repeat the foregoing experiment with a little sulphuric æther, instead of rum. Observe that much less heat is sufficient to volatilize the æther. It may be made to boil by merely immersing the body of the retort in hot water, which, when applied to this purpose, is called a *water bath.* The vapour of æther is also more difficult to condense into a liquid than that of either alcohol or water, and the receiver ought to be surrounded with pounded ice or snow. Some substances require the aid of very powerful freezing mixtures for this purpose. Æther boils, and continues in the form of vapour, or as we have expressed it, a "temporary gas," at a heat little higher than that of the human body. Vide *Exp.* 108.

Exp. 26.—Repeat the same experiment (on a very small scale,) with mercury. This substance requires more heat for its volatilization, and is so easily condensed, that the receiver need not be surrounded with water, which, besides, would render the glass liable to crack, from the heat of the mercurial vapour.

In distilling some of the more volatile substances it is often necessary to render the joint between the retort and the receiver *air-tight,* to prevent the escape of uncondensed vapour. For the tube retort and receiver, a short tube of caoutchouc may be employed, which is very effectual, and is exceedingly useful in many other cases, as in forming flexible and air-tight joints between tubes for the conveyance of gases. Caoutchouc is softened and dissolved by æther, (and cannot therefore be employed in *Exp.* 25,) but it in general resists the action of acids, and even the most corrosive vapours and gases. Sometimes we select a bung cork, which exactly fits into the neck of the receiver, and by means of a round file bore a hole in it, which exactly receives the beak of the retort. This joint, if necessary, is made secure by being plastered with lute. Or the joint may be made air-tight by the lute alone, without the cork.

SUBLIMATION.

Exp. 27.—Put a few particles of iodine into a test tube or flask, and apply heat. The iodine will become converted into a beautiful violet coloured vapour. On cooling, it will be condensed in the upper and cooler part of the tube in its original solid state. It is then said to be *sublimed.* Sublimation differs from distillation only in being applicable to solid, instead of liquid substances; and these are often condensed in regular crystaline forms.

Exp. 28.—Repeat the last experiment, with other volatile solid substances; as calomel, muriate of ammonia, camphor, &c.

Exp. 29.—Mix together very thoroughly equal portions of muriate of ammonia, and dried sub-carbonate of soda. Expose the mixture to heat in a test tube. *Double decomposition* will take place:—carbonate of ammonia, known by its pungent smell and taste, will be sublimed into the upper part of the tube, while muriate of soda, or common salt, will be formed below. Vide *Exp.* 19.

COLLECTING AND EXPERIMENTING ON GASES. AMMONIA. MURIATIC ACID.

The best general mode of collecting gases for experiments is by means of the pneumatic trough. They may often, however, be obtained in a sufficient state of purity for many purposes without the aid of that apparatus.

Exp. 30.—Select a very sound cork which will fit into the mouth of a flask, and with a round file bore a hole that will admit a piece of straight glass tube. Then having introduced a little solution of ammonia into the flask, fix the cork containing the tube into its mouth, and if the joint be not air-tight, make it so by means of lute. Apply heat, when an effervescence will take place, at a much lower temperature than would be required to boil water; which effect arises from the expulsion of the ammoniacal gas, previously held in solution by the water. This rising through the tube, will soon make itself perceptible by the pungent smell at the open end of it. Ammonia is lighter than common air; and if a small air-jar be turned with its mouth downwards, so that the glass tube may pass inside to the top of it, the gas will, by degrees, occupy the whole of the jar, perfectly invisible, but possessing a strong smell, similar to that of hartshorn. So long as the jar is kept in this position, the gas will escape but slowly: but if it be turned with its mouth upwards, the gas will, from its lightness, ascend, and be instantly lost. By having the mouth of the jar ground flat, and when filled, removing it slowly in the same position from the tube, and closing it with a piece of plate glass, the gas may be confined for some time. A little gas may even be collected in a large test tube, or a phial, and this afterwards closed by means of a cork.

Exp. 31.—Moisten a slip of turmeric paper with water, and push it up into the jar or tube containing ammoniacal gas. It will be reddened, proving this gas to be alkaline.

Exp. 32.—Repeat *Exp.* 30 with muriatic acid, instead of ammonia, and employing instead of a straight tube, one bent twice at right angles, with or without a flexible joint of caoutchouc. Heat will disengage muriatic acid gas, which being heavier than common air, will not remain in a jar which has its mouth downwards any more than water would. The tube must therefore be carried to the bottom of a jar that has its mouth upwards; and when this is filled, the gas may be secured by a plate glass as before.

Exp. 33.—Introduce a slip of moistened litmus paper into a jar containing muriatic acid gas. The blue colour will be converted to red, proving the gas to be an acid.

Exp. 34.—Place a jar containing ammoniacal gas perpendicularly over a jar containing muriatic acid gas, both being secured by pieces of plate glass. Then quickly slip away the two pieces of plate glass, so that the mouths of the two jars may be brought into immediate and close contact. Reverse their position, and bring the muriatic acid uppermost; the two invisible gases will then combine, producing a dense white fume, which will presently settle on the sides of the glass in the form of a powder. We have here an instance of the union of two gases, forming a compound differing in its properties from both, the powder being common muriate of ammonia.

Exp. 35.—Gases heavier than air may be poured like water from one vessel into another. Put a slip of litmus paper moistened with water into the bottom of an ale or wine glass; then pour the invisible muriatic acid gas out of a jar into the glass, when the litmus will be immediately reddened.

COMPOSITION OF WATER. HYDROGEN GAS.

Water is a compound substance, formed by the union of two gases, hydrogen and oxigen, as may be proved by separating it into these two elements, and afterwards re-producing the water by causing them to unite again. (The separation of the elements of a compound body from one another is called *analysis:* the combining of these elements together so as to form the compound is called *synthesis.* For the synthesis of water see *Exp.* 92.) Oxigen cannot be separated from water *directly*, except by the galvanic battery; but it may be made to combine with some other substance having a stronger attraction for it, while the hydrogen is set free. If water, in the form of vapour, be made to pass over iron turnings, heated to redness in a gun-barrel, the iron will combine with the oxigen, forming oxide of iron, and the hydrogen will be set free. But at common temperatures, iron will not produce this effect without some other aid. Now oxide of iron and sulphuric acid have a strong attraction for each other. To elucidate the effect by a figure of speech that will express more fully the effect, we may say they are *fond of combining*. If, then, iron, water, and sulphuric acid be mixed together, the acid offers the iron an inducement to exert additional strength of attraction, and to decompose the water by seizing its oxigen; thus converting itself into an oxide, for the sake of being in a condition to combine with the acid; for it is incapable of this combination, except when in the state of oxide. This is called a *disposing affinity*, and is of frequent occurrence in chemistry.

Exp. 36.—Into a bottle containing some iron filings, or what is better, granulated zinc, pour sulphuric acid, diluted with about six times as much water. Effervescence will commence, without the aid of heat, from the escape of the hydrogen gas. If a piece of tobacco pipe, or glass tube drawn to a somewhat fine point, be fixed in the bottle by means of a bored cork, the gas may be set on fire as it issues from the tube, and will burn with a pale flame, yielding little light, but much heat, as may be proved by holding a bit of fine iron wire in it.

In this experiment, the gas must not be lighted until the effervescence has been going on briskly for some minutes, to allow time for the complete expulsion of the air previously contained in the bottle. Otherwise an explosion might take place, sufficient to blow out the cork, if not burst the bottle.

On evaporating the liquor remaining in the bottle, we may obtain crystals of sulphate of iron, or of sulphate of zinc, as the one or the other of these metals may have been dissolved.

USE OF THE PNEUMATIC TROUGH.

Exp. 37.—Fill the pneumatic trough with water to about an inch and a half above the shelf. Let the air-jar intended to receive the gas be filled with water, and carefully placed on the shelf (with its mouth downwards, and without allowing any air to enter it), immediately over one of the holes, or projecting a little over the edge of the shelf. Then having put the materials for forming the gas (as in *Exp.* 36) into a gas-bottle with a curved tube, immerse the end of the tube in the water, immediately under the air-jar. The gas as it issues will rise in bubbles into the air-jar, and gradually displace the water which previously occupied it. The first bubbles that come over are unfit for use, containing the air which previously occupied the upper part of the gas-bottle and its tube; but it is best to collect them in order to be sure when considerably more than the bulk of this air has passed over. Afterwards collect the gas for use as long as it continues to be generated, changing the jars as they become filled, and not allowing all the water to be expelled from them, lest they be rendered too light and upset.

The gases may be shifted from the shelf of the trough, by slipping a saucer or any similar vessel under the mouth of the air-jar, taking care that this be effected entirely below the surface of the water; then remove the jar on the saucer to a convenient place, having left so much water in the saucer that the mouth of the jar may be completely immersed.

The gas may be transferred from one jar to another, under water, by placing the mouth of the jar which is to deliver under that of the jar which is to receive, the latter having been previously filled with water. On then inclining the former jar gradually, all the gas will pass in bubbles into the other. For transferring a gas into a tube, a small inverted funnel should be employed.

Exp. 38.—Take a bladder which is mounted with a stop-cock, and well emptied of its air, and connect it by means of a brass connecting piece with the stop-cock of a transfer jar, both cocks being closed. Pass hydrogen gas into the transfer jar, as in the last experiment, and when it is filled to below the level of the water, open both cocks: the gas will then pass into the bladder. When almost enough has been collected, sink the jar deeper into the water, to force the remaining gas into the bladder, in which it may be removed after closing the cock.

ABSORPTION OF GASES BY LIQUIDS.

Exp. 39.—Fill a jar or tube with ammoniacal gas, and immerse its mouth in water. The water will absorb the gas rising into the jar; and would fill it completely, if the gas were pure. Such gases as are absorbed by water cannot be collected over the common pneumatic trough, but require the aid of the *mercurial trough.* Only chlorine and a few other gases have any action on mercury.

Exp. 40.—Pour sulphuric acid, previously diluted with an equal quantity of water and allowed to cool, on some common salt, contained in a flask to which a bored cock, containing a bent tube, has been adapted

(*Exp.* 30). The mixture, on the application of a gentle heat, will effervesce, from the escape of muriatic acid gas. Let the open end of the tube be but just immersed in a little water contained in a wine glass or a phial. As soon as the common air has escaped, few or no bubbles will rise through this water, the gas being rapidly *absorbed* by it. Were the gas produced too slowly, the absorption would even cause the water to return up through the tube into the flask. The water will become warm (see *Exp.* 68), and acquire more and more of an acid taste, until at last it is saturated with the gas, and fumes strongly on exposure to the air. It has become liquid muriatic acid, which when quite pure is colourless; the common acid of commerce owing its yellow colour to the presence of a little iron. Water absorbs several hundred times its own bulk of this gas.

Rationale of the decomposition in the foregoing experiment. Common salt (or chloride of sodium), is a compound of chlorine (which is a yellow gas), and sodium (a metal, brilliant as silver); and muriatic acid gas is a compound of chlorine and hydrogen. When sulphuric acid is added to the salt, water being at the same time present, a *disposing affinity* is produced. The sodium combines with oxigen of the water, forming soda, with which the sulphuric acid unites, and the sulphate of soda remains in the flask; while the chlorine combines with hydrogen of the water, forming muriatic acid gas, which passes over.

Exp. 41.—Pour diluted muriatic acid on a few lumps of white marble (carbonate of lime), in a flask, to which the bent tube is adapted. Muriate of lime will be formed in the flask (or rather chloride of calcium, from a change the reverse of that explained in the last experiment), and carbonic acid gas will pass over. This gas is but a weak acid, and water may be made to absorb it as in the last experiment, but only in very small quantity, i.e. little more than its own bulk. To promote this absorption, the end of the tube may be inserted into the bottom of a phial, nearly half filled with very cold water, and when enough of gas has passed to displace the air and occupy all the upper part of the phial, the tube may be removed, the thumb applied to the mouth of the phial, and the water well shaken with the gas. The absorption will be obvious by the suction against the thumb, and this operation may be repeated several times, when the water will have acquired a slight and agreeable acid taste; differing not from common soda water, except that the latter is made in a machine, by means of which it can be more highly charged with the gas.

To impregnate water with chlorine, sulphuretted hydrogen, and other gases, sparingly absorbed by it, the same method may be adopted; while ammonia, sulphureous acid, and such gases as are readily absorbed do not require the assistance of agitation. However, in making liquid ammonia, the tube should dip to near the bottom of the water, because the liquid ammonia being lighter than water, would otherwise remain at the surface, and prevent the contact of the gas with the unimpregnated part of the water without frequent agitation. Liquid muriatic acid is heavier than water; and (as in mixing water with spirit), may be seen falling in striæ to the bottom as fast as formed: the whole, however, eventually blending perfectly.*

COMPOSITION OF THE ATMOSPHERIC AIR. OXIGEN. NITROGEN. OXIDES AND THEIR REDUCTION.

Atmospheric air is a mixture of oxigen and nitrogen gases, containing also a very small portion of carbonic acid, about one part in a thousand. When combustible bodies are heated in the air, they absorb and combine with its oxigen in the act of burning, and form what are called *oxides*; while the nitrogen remains alone.

Exp. 42.—Support a small copper or tin dish, or even a watch glass, containing a piece of phosphorus the size of a pea, previously dried by laying it on some filtering paper, upon any convenient stand, a few inches above the surface of some water in a basin. Set fire to the phosphorus by means of a hot wire, and quickly invert a jar over it, so that the mouth of this may be immersed below the water. As the phosphorus ceases to burn, and the whole becomes cool, the water will rise in the jar, and occupy about one-fifth of its capacity, in the place of the oxigen, which has combined with the phosphorus. The remaining gas is *nitrogen*, not quite pure, and it is no longer capable of supporting the combustion even of phosphorus. A considerable number of oxidized substances are acids, as in the present instance.

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* For the purpose of passing a gas through a liquid very conveniently on a small scale, I have constructed a tube in the form of the letter U, with a bulb in each side. As much liquid is introduced as will two-thirds fill the lowest bulb, and one end is then connected with a tube or retort, delivering the gas. The liquid remains in one or the other of the bulbs, according as the gas is more or less rapidly absorbed.

Exp. 43.—Heat some red oxide of mercury strongly in a small test tube; it will shortly become converted into ordinary quicksilver, and is then said to be *reduced to the metallic state.* In this case oxigen gas is given off, and may be collected over the pneumatic trough, when it will be found to possess singular properties. The characteristic of oxigen gas is, that ordinary combustible bodies will burn in it with many times more energy and brilliancy than in common air. This may be shewn by lighting a slender match of deal wood, then blowing out the flame, and inserting the end, still red hot, into the test tube, so that it may be immersed in the gas which the oxide of mercury is giving off. The match will instantly burst into flame again, and burn brilliantly for a second or two. See *Exp.* 76 and 77.

Exp. 44.—Most oxides are incapable of being reduced by mere heat; they therefore require the addition of some other substance, which at a high temperature, has a stronger attraction for the oxigen. Mix some red oxide of lead, with one-fourth as much charcoal powder; put the mixture into the bowl of a tobacco pipe, and heat it to redness in a common fire for ten minutes. The charcoal will combine with the oxigen, forming carbonic acid gas, which will fly off; whilst the lead will be reduced into metallic particles.

If, instead of charcoal, we employ *black flux*, which is a mixture of charcoal with carbonate of potass, this substance will melt at a very strong red heat, and give the reduced lead an opportunity of settling to the bottom, and collecting into one mass, or as it is called, a button.

Many of the common metals are found in nature in the state of oxide, and are on the foregoing principle, reduced to the metallic state.

A metallic oxide may often be reduced by passing over it at a red heat, an inflammable gas, as hydrogen, or the decomposed vapour of oil, as in blow-pipe experiments.

ON THE USE OF THE BLOW-PIPE.

The blow-pipe is invaluable to the experimental chemist, affording the readiest and most economical means of examining, with considerable precision, the properties of a large class of bodies. It is therefore of constant use in assaying, in the chemical examination of minerals, &c. It produces the effects of a furnace, upon small particles of matter, in a few minutes.

It is well worth while to bestow some pains in acquiring the skilful use of this instrument, and the beginner is recommended to pursue the following plan:—

1st.—Practice breathing through the nostrils alone while the mouth is closed.

2d.—Distend the cheeks with air while the mouth is closed, and breathe freely for a long time without disturbing the position of the cheeks. Practise this until it becomes quite easy.

3d.—Hold a blow-pipe between the lips; then distend the cheeks as before, breathing through the nostrils. Before the distention of the cheeks has completely ceased, by the air passing through the aperture of the blow-pipe, refill them from the chest, still breathing by the nostrils, so that there may be an uninterrupted current of air through the blow-pipe. Repeat this till the practice of it becomes easy.

4th.—Place the jet of the blow-pipe just outside the flame of a candle, and less than a quarter of an inch above the top of the wick, which should be rather short, and turned a little on one side forwards. Then blow, as just directed, through the blow-pipe; the current of air will carry the flame in a horizontal direction, in the form of a lengthened cone. Practice blowing and holding the instrument steadily, so as to produce a uniform, uninterrupted jet of flame, for five minutes or more at a time.

A small lamp, constructed and sold for the purpose, is preferable to a candle, and a wax candle is preferable to a tallow one. The wick should be slightly divided in the middle, and the nozle of the blow-pipe being held opposite the division, must be adjusted at the distance whence it produces the best jet or pencil of flame. If it be held close to the flame, it will produce a long, slender jet; if at a certain distance, a broken, broad, and roaring flame; and both of these are occasionally required in different cases: the latter heating a greater surface, but in a less intense degree.

The blow-pipe may be considered to turn the flame inside out, by supplying it with air from within.

It is necessary to observe that the jet consists of three parts; an inner blue flame; an outer flame, which is yellow; and a third part faintly coloured, bordering on the yellow flame. In the *blue* part, the combustion is not yet complete; there is a great excess of combustible matter, and if a piece of glass be held for two or three seconds in this part, a black carbonaceous matter will be deposited upon it, which will not be the case in the outer border of the yellow flame, or just beyond the extreme point of the jet; for here the carbonaceous matter may be burnt off again. The greatest heat is, in general, just beyond the inner blue, and where this merges into the yellow flame. At this point, a particle of matter may often be brought to a white heat, in a few seconds, by good management.

The substance to be exposed to the blow-pipe flame, from the size of a pin's head to that of a pea, or larger, may be supported on a piece of charcoal, platina foil, a hooked platina wire, or between a pair of forceps, the tips of which are of platina.

The subject of experiment is heated either by itself, or mixed with some flux, such as borax, microcosmic salt, &c.

Exp. 45.—Take a piece of alderwood charcoal, make a slight cavity towards one end of it, and introduce into this a particle of tin, the size of a very large shot. Direct the flame of the blow-pipe upon it, and produce the greatest possible heat. Keep the tin constantly enveloped in the flame, and as long as it is so, it will preserve its metallic state, and remain untarnished; but immediately it is outside the flame, it will begin to be oxidized at the surface. (Vide *Exp.* 41.) Practise this experiment repeatedly with a larger and larger piece of tin, always endeavouring to keep it bright, by enveloping it in the flame, and thus preventing the contact of the air. Alderwood charcoal is generally free from the cracks and cavities common in that obtained from many other woods.

Exp. 46.—Expose a particle of zinc on the charcoal to a bright red or white heat. The metal will burn with a beautiful flame, emitting a dense smoke, which is *oxide of zinc*. Some of this will be deposited on the charcoal as a white powder.

Exp. 47.—Make a shallow cavity in the bottom of a small Hessian crucible, and introduce a particle of lead. Expose this to the outermost part of the flame for a considerable time, until it is converted into a yellow or red oxide. Then expose it to the blue flame, when the lead will be partially or totally reduced. The reduction is best effected on charcoal.

Exp. 48.—Hold a small piece of flint glass tube in the inner flame for a few minutes, applying the heat gradually at first, to avoid cracking it. Wipe off the smut, and observe the black stain produced on the glass by the inner flame. This cannot be wiped off, and has been produced by the superficial reduction of the oxide of lead, which is one of the ingredients of flint glass. If the stain be slight, it may be removed by holding it for some time just outside the outer flame, which will re-oxidize the lead.

Exp. 49.—Expose a particle of metallic arsenic to the outer flame. It will presently volatilize, being at the same time oxidized, and emitting a fœtid smell resembling garlic, which is characteristic of this metal.

Exp. 50.—Put a grain, more or less, of common white arsenic (which is the oxide of the metal), into the bulb of an arsenic tube, with as much powdered charcoal as will cover it. With a slender feather, or a bit of twine, clear the fine part of the tube from the dust, and then heat the bulb gently over the spirit lamp, or if necessary, by the blow-pipe. The arsenic will be reduced, and sublimed in a metallic state, into the narrow part of the tube, or just above. In this way, a very minute quantity of arsenic may be detected in any dry powder supposed to contain it.

Exp. 51.—Heat some *native* cobalt (which is the ore of that metal as found in the earth, and contains several other metals), on the charcoal. It will emit a white smoke, with a smell of garlic from the expulsion of arsenic. Bend a piece of platina wire into a hook at one end, wet it, and dip it into powdered borax, until a sufficient quantity adheres; add the cobalt to this, and expose to a strong heat in the flame, so that the cobalt and borax may melt together into a globule or bead. This, when cold, will be observed to possess a beautiful blue colour, characteristic of cobalt. The products of blow-pipe experiments in general, are best examined with a magnifying glass, and by day-light.

Cobalt in the form of zaffre or smalt, is used in making blue glass, and in producing the blue colours on enamelled porcelain; a very minute portion of it being sufficient to communicate a rich deep colour. Various colours are produced by the oxides of other metals.

Exp. 52.—Expose a small particle of oxide of manganese, mixed with borax, to the outer flame of the blow-pipe. It will acquire an amethyst colour, which will disappear in the inner, and re-appear in the outer flame, and so on alternately.

Exp. 53.—Mix a little muriate, or almost any other salt of nickle, with borax, and expose it to the outer flame. It will acquire a red colour, which will become less intense, or even disappear altogether on cooling.

Exp. 54.—Expose a little oxide of bismuth, mixed with carbonate of soda, on the charcoal support, to the inner flame. A globule of metallic bismuth will be formed. Separate this, give it a slight blow with a clean hammer on an anvil, or other smooth hard surface, and it will prove brittle. Examine the fragments with a microscope.

Exp. 55.—Treat oxide of lead as in the last experiment. The reduced globule will not prove brittle, but may be flattened under the hammer.

Repeat the same with oxides or salts of antimony and tin.

In experiments with metals, or where metals are expected to be reduced, platina supports are inadmissible, because the reduced metal will alloy with, and fuse them. In these cases, we must resort to charcoal, or a support made of dried clay.

Exp. 56.—Try the effect of the blow-pipe flame on small particles of various metals. Lead, tin, bismuth, antimony, &c. will readily fuse. Others, as silver, copper, and gold, will fuse at a higher temperature; and others again, as platina, are infusible with the utmost heat that can be produced. Most of them become tarnished, or oxidated at the surface, when exposed to the outer flame; but gold, silver, and platina, remain unchanged. These latter are sometimes called *noble metals.*

Exp. 57.—Expose a particle of sulphate or any other salt of copper, or the peroxide mixed with microcosmic salt, to the blow-pipe flame. A green colour will be communicated to the outer flame.

Exp. 58.—Put a little sulphate of magnesia on a charcoal support, and expose it to a red heat before the blow-pipe. Then moisten it with a solution of nitrate of cobalt, and again heat it strongly. The product will have acquired a red colour.

Exp. 59.—Substitute a particle of pipe clay (impure alumina), for sulphate of magnesia in the last experiment. It will acquire a blue colour.

Exp. 60.—To a grain or two of carbonate of strontia, add a drop of muriatic acid; cause the mixture to adhere at the hooked end of the platina wire, and when dry, expose it to the point of the inner flame. The outer flame will acquire a beautiful carmine colour, which, however, will presently disappear. By this disappearance, we may distinguish strontia from lithia.

Exp. 61.—Mix intimately together equal parts of sulphuret of mercury (cinnabar or vermillion), and dried carbonate of soda, and put the mixture into the sealed end of a small glass tube. A common test tube may be used for the purpose, but green glass, being harder, is preferable. Remove any adhering dust from the inside of the upper part of the tube with a small feather. Then expose the sealed end, where the mixture lies, to the blow-pipe, until it becomes red hot. Metallic mercury will rise in vapour, and condense against the upper part of the tube, in the form of a gray powder, which consists of minute globules, as the microscope will prove. On collecting these particles together with a glass rod, they will be more distinctly seen to be mercury.

PART II.

A concise EPITOME OF CHEMISTRY; *containing a description of the leading properties of all the simple substances, and their principal combinations.*

OXIGEN.

A permanent gas. Powerful supporter of ordinary combustion, and of respiration.

NITROGEN.

A permanent gas. Supports neither respiration nor combustion.

COMPOUNDS OF OXIGEN WITH NITROGEN.

Protoxide of nitrogen, often called *laughing gas.* Supports combustion. Intoxicates when inhaled into the lungs.

Deutoxide of nitrogen, or nitrous gas. Irrespirable. Produces red fumes when mixed with air, or with oxigen; nitrous acid being generated.

Nitrous acid. A red volatile liquid.

Nitric acid. A colourless liquid. Dissolves many metals, yielding its oxigen to them. Caustic. Commonly called aqua-fortis.

HYDROGEN.

A permanent gas and the lightest body known. Inflammable. When mixed with common air, and more particularly with half its bulk of oxigen, forms a dangerous explosive mixture. Inflamed by spongy platina. Its combustion produces water.

COMPOUNDS OF HYDROGEN WITH OXIGEN.

Water.

Peroxide of hydrogen.

COMPOUND OF HYDROGEN WITH NITROGEN.

Ammonia. A gas lighter than air, with a pungent smell like hartshorn. Alkaline. Readily absorbed by water.

CARBON.

In its purest form is the diamond. Its ordinary state charcoal, or lamp-black.

COMPOUND OF CARBON WITH OXIGEN.

Carbonic oxide. A gas. Burns with a lambent blue flame.

Carbonic acid gas. Twice as heavy as air. Extinguishes flame. Irrespirable. Rapidly absorbed by lime, and the pure alkalies. Generated during vinous fermentation, and by the respiration of animals. Constitutes $\frac{1}{1000}$ of the atmosphere.

COMPOUND OF CARBON WITH NITROGEN.

Cyanogen gas. Burns with a carmine coloured flame. Absorbed by water. Combines with hydrogen, forming hydrocyanic, or prussic acid. Though a compound, cyanogen is analogous in general properties to chlorine, bromine, and iodine.

COMPOUNDS OF CARBON WITH HYDROGEN.

Protocarburetted hydrogen gas. Much lighter than air.

Percarburetted hydrogen, or olefiant gas.

Both burn with a white illuminating flame, and are the principal ingredients of coal gas.

Several others; as *naptha, &c.*

SULPHUR, OR BRIMSTONE.

COMPOUNDS OF SULPHUR WITH OXIGEN.

Sulphureous acid gas. Product of the combustion of sulphur. Suffocating. Absorbed by water. Bleaches.

Sulphuric acid. The *anhydrous* is solid, very volatile, resembles asbestos in appearance, and fumes in an extraordinary degree when exposed to the air. Combines greedily with water.

The *ordinary* sulphuric acid contains a portion of water, and is commonly called *oil of vitriol.* Nearly twice as heavy as water. Requires a high temperature to boil it. Absorbs moisture from the air.

Hyposulphureous and *hyposulphuric acids.*

COMPOUND OF SULPHUR WITH HYDROGEN.

Sulphuretted hydrogen gas. Fœtid smell, resembling rotten eggs. Highly poisonous. Precipitates the common metals from their solutions, except iron, manganese, zinc, nickle, and cobalt: forming precipitates of various colours. Sparingly absorbed by water: rapidly by alkaline solutions. An acid.

COMPOUND OF SULPHUR WITH CARBON.

Sulphuret of carbon. A highly inflammable and volatile liquid. Heavier than water. Fœtid smell.

PHOSPHORUS.

Consistence of wax. Highly inflammable, shining in the dark, taking fire with very moderate warmth, and burning brilliantly. Burns with insupportable brilliancy in oxigen gas. Poisonous.

COMPOUNDS OF PHOSPHORUS WITH OXIGEN.

Phosphoric acid. Product of the combustion of phosphorus. Intensely acid, but not caustic.

Phosphorous, *hypophosphoric*, and *hypophosphorous acids.*

COMPOUND OF PHOSPHORUS WITH HYDROGEN.

Phosphoretted hydrogen gas. Takes fire spontaneously in the air. Very fœtid smell, resembling garlic.

SELENIUM.

A dark coloured solid, recently discovered, analogous in general properties to sulphur, and forming corresponding combinations.

BORON.

A dark olive coloured powder, forming boracic acid by combination with oxigen.

Boracic acid. Little soluble in cold water, more so in hot. Little taste. Fuses into a glass.

SILICON.

A brown powder, forming silica by combination with oxigen.

Silica. Abundant in nature, existing almost pure in rock crystal and in flints. The principal ingredient of sand, &c. Insoluble in water. When melted with the fixed alkalies, forms glass.

CHLORINE.

A yellow, heavy, suffocating gas. Sparingly absorbed by water. Bleaches. Phosphorus and some of the metals take fire in it spontaneously. Combines with all the metals, forming chlorides.

COMPOUNDS OF CHLORINE WITH OXIGEN.

Protoxide of chlorine. *Deutoxide of chlorine.* Gases, more deeply yellow than chlorine. Dangerous from their exploding with violence when gently warmed. Absorbed by water.

Chloric acid. Easily decomposed. Never obtained separate from water.

Perchloric acid. A somewhat powerful acid.

COMPOUND OF CHLORINE WITH NITROGEN.

Chloride of nitrogen. An oily looking fluid. The most powerfully explosive substance known.

COMPOUND OF CHLORINE WITH HYDROGEN.

Muriatic acid gas. Powerful acid. Water absorbs 800 times its bulk. Produces fumes by mixture with air, from combining with its water.

COMPOUNDS OF CHLORINE WITH CARBON.

Chlorides of carbon, of which there are two or more.

COMPOUNDS OF CHLORINE WITH SULPHUR, PHOSPHORUS, SELENIUM, AND BORON.

Chloride of sulphur. Orange coloured liquid, having an irritating smell.

Chlorides of phosphorus. The one solid. The other liquid. Volatile.

BROMINE.

A very heavy, brown liquid; so volatile that it is difficult to confine in bottles. With a gentle warmth converted into an orange coloured vapour. Diffuses an exceedingly powerful, irritating smell, not unlike chlorine, which substance it much resembles both in its properties and its combinations.

IODINE.

A black solid, converted by gentle heat into a beautiful violet coloured vapour, having a powerful smell. Easily sublimed. Forms compounds analogous to those of chlorine and bromine. Poisonous.

COMPOUND OF IODINE WITH OXIGEN.

Iodic acid. A white solid, decomposed by heat.

COMPOUND OF IODINE WITH NITROGEN.

Iodide of nitrogen. An explosive black powder.

COMPOUND OF IODINE WITH HYDROGEN.

Hydriodic acid gas. A very heavy gas, much more readily absorbed by water than even muriatic acid.

FLUORINE.

Little, or not at all known in a pure state, owing to its energetic tendency to combination, and especially with silicon, which renders it impossible to experiment, in vessels of glass, with many of its combinations. Has been presumed to be almost a universal solvent.

COMPOUND OF FLUORINE WITH HYDROGEN.

Hydrofluoric acid. Commonly called fluoric acid. When undiluted with water, a volatile fuming liquid, a minute particle of which causes a severe and painful wound on the skin. Dissolves glass, and must therefore be prepared in vessels of lead, silver, gold, or platina.

METALS.

Metals are opaque, and possess a peculiar lustre called the metallic lustre. They are capable of entering into combination with oxigen, chlorine, bromine, iodine, fluorine, and cyanogen, forming oxides, chlorides, &c. Some of the metallic oxides are acids, others are alkaline; the remainder belong to neither of these classes of bodies. The greater part of those which are not acids, are capable of entering into secondary combinations with the acids forming neutral salts. Metals combine also with sulphur, phosphorus, and selenium, forming sulphurets, &c. And a few of them combine with carbon, hydrogen, &c.

CLASS I.

Metals, of which the oxides are alkaline, and soluble in water.

POTASSIUM.

A singular metal, the colour of quicksilver, about as hard as wax, and lighter than water. Remarkable for its energetic attractions, especially for oxigen, which it absorbs from the air, its surface becoming instantly tarnished. Decomposes water, and even ice, at the same time burning brilliantly.

Oxide of potassium. Potass. Caustic. Very soluble in water, which it absorbs from the air, with carbonic acid at the same time.

SODIUM.

Effervesces rapidly in water, but without burning. Colour of silver. Its oxide, caustic soda, is very similar to potass.

Chloride of sodium. Common sea salt.

LITHIUM.

The base of a very rare alkali, lithia.

Lithia. Many of its salts remarkable for their insolubility, compared with those of potass and soda.

BARIUM.

Heavier than water. Little known.

Baryta, or oxide of barium. Gray colour. Soluble in water, forming baryta water. Caustic. Alkaline taste. Absorbs carbonic acid from the air; its solution, when exposed, becoming covered with a pellicle of carbonate of baryta, which is insoluble. Poisonous.

STRONTIUM,

And its compounds. Resembling baryta.

CALCIUM.

A white metal.

Oxide of calcium. Common lime. Sparingly soluble in water, forming lime water. Produces heat when water is poured on it. One of the most infusible bodies known. More soluble in cold than in hot water.

Chloride of calcium. Very deliquescent. Employed for drying gases, which are freed from the water they contain, by being passed through a tube containing fragments of this substance.

Fluoride of calcium. Fluor, or Derbyshire spar.

Phosphuret of calcium. Commonly called phosphuret of lime. A reddish brown substance, which decomposes water, forming phosphuretted hydrogen, &c.

MAGNESIUM.

Oxide of magnesium, or magnesia. Little taste. Very sparingly soluble in water. Possesses faint alkaline properties.

CLASS II.

Metallic bases of the Earths.

ALUMINUM.

A gray powder, in which lustre may be produced by pressure between steel or agate surfaces. Inflammable at a red heat. Does not easily decompose water.

Oxide of aluminum. Alumina. A white insoluble powder, the principal ingredient of clays.

GLUCINUM. YTTRIUM. ZIRCONIUM.

The metallic bases of glucina, yttria, and zirconia, which are rare earths.

CLASS III.

Comprising the more oxidable of the common metals, which decompose water at a red heat.

MANGANESE.

Very infusible. Decomposes water slowly, even at common temperatures. Brittle.

Oxides of manganese. Protoxide. Colour light green. Takes fire at a red heat, producing the red oxide.

Deutoxide, or red oxide.

Peroxide. Yields a portion of its oxigen when heated, leaving the deutoxide.

Manganic, and permanganic acids. Not obtainable in a separate state. The first, in combination with potass, forms the mineral chameleon.

IRON.

Very hard and difficult of fusion. Attracted by the magnet, which property is possessed by no other metals except nickle and cobalt. Oxidates rapidly at a red heat in the common air, and burns in oxigen gas. Precipitates many of the other metals from their solutions.

Oxides of iron. Protoxide. By exposure to the air, rapidly converted into the peroxide. Most of its combinations with acids are green; they absorb oxigen from the air, and the iron they contain is also converted into peroxide, by boiling with a little nitric acid. They deoxidize solutions of gold, reducing it to the metallic state.

Peroxide. Red. Most of its combinations with acids are red. They produce a black precipitate with infusion of galls.

Carburet of iron. Common steel. Remarkable for its hardness. Cast iron is another carburet, but contains impurities.

Sulphuret of iron. The protosulphuret, when dissolved in sulphuric or muriatic acid diluted with water, evolves sulphuretted hydrogen gas.

ZINC.

Brittle at ordinary temperatures, but malleable a little above the boiling point of water. Fusible below a red heat. Volatile at a white heat. Burns brilliantly at a high temperature, producing the oxide, which is white.

CADMIUM.

Colour of tin. Ductile and hard. Very fusible.

TIN.

White colour. Very fusible. Not tarnished or oxidized by mere exposure to air, and therefore used for covering sheet-iron, which in this state is called tin-plate.

Oxides. Solutions of the protoxide attract oxigen powerfully, and even deoxidize solutions of the peroxide of iron.

Peroxide. A white or straw coloured powder, little soluble in acids.

CLASS IV.

Metals which do not decompose water, and are incapable of reduction by heat alone.

The oxides of the six first are distinct acids.

ARSENIC.

Brittle. Volatile and easily sublimed. Colour white, but soon tarnishing on exposure to air. When heated in the air, emits a smell of garlic.

Oxides. Arsenious acid, or common white arsenic. Volatile. Sparingly soluble in water. Combines with alkalies, &c. Highly poisonous.

Arsenic acid. Very soluble in water. Poisonous.

Arsenuretted hydrogen gas. Fœtid. Probably the most poisonous of the gases.*

Sulphurets of arsenic. Of a red or yellow colour.

CHROMIUM.

Difficult to reduce. Brittle and very infusible.

Oxides. Green oxide. Unites with acids.

* Gehlen, professor of the academy of Munich, wishing to ascertain by the smell at the orifice of the vessel in which he was preparing this gas, whether its production had commenced, was attacked an hour after with severe headache, vomiting, and debility. These symptoms continued to increase, and he died nine days after in horrible agony and convulsions. Of most of the deleterious gases, the effects appear to be more immediate, but more evanescent.

Chromic acid. Red and soluble in water. Forms beautifully coloured salts with many of the bases.

VANADIUM.

A recently discovered metal.

MOLYBDENUM.

Very infusible.

Molybdic acid. Sparingly soluble in water.

TUNGSTEN.

Very infusible. Hard and brittle.

Oxide of tungsten. Colour brown.

Tungstic acid. An insoluble yellow powder.

COLUMBIUM.

A rare, and very infusible metal. Combines with oxigen in two proportions, forming

Oxide of columbium, and

Columbic acid.

ANTIMONY.

Of a whitish colour. Brittle, and fusible at a low red heat.

Protoxide of antimony. The base of the salts of antimony, as tartar emetic, &c.

Deutoxide.

Peroxide, or *antimonic acid.* Combines with the alkalies, &c.

COBALT.

Of a gray colour, and brittle. Nearly as difficult of fusion as cast-iron.

Protoxide. Colour ash gray, or brown. Combines with acids, forming salts which are generally of a pink colour. This oxide, when in combination with water, forms the *hydrated oxide,* which is blue.

Peroxide black. Insoluble in the common acids, except muriatic.

NICKLE.

Nearly as white and brilliant as silver. Ductile and malleable. More infusible than cast-iron. Not oxidated by air or moisture. It is the basis of the various imitations of silver, such as the German and British plate, &c. Closely resembles cobalt in its affinities.

Protoxide. Colour ash gray. Salts green.

Peroxide. Black. Does not unite with acids.

BISMUTH.

Whitish and crystaline. Brittle. More fusible than lead.

Oxide. Very white. Sometimes used for painting the skin.

CERIUM.

Little known. Its *oxides* are white and fawn coloured powders.

URANIUM.

Little known.

Protoxide. Green.

Peroxide. An orange yellow powder.

TITANIUM.

Copper coloured. Hard, and very infusible.

Protoxide. Purple.

Peroxide. White. Possessing slight acid properties.

TELLURIUM.

Lead coloured. Fusible as zinc. Inflammable.

Oxide. Gray. Combines both with acids and alkalies.

Telluretted hydrogen. A gas, somewhat resembling sulphuretted hydrogen.

COPPER.

Ductile, malleable, very tough and tenacious. Fusible at a strong red heat. Poisonous.

Protoxide. Red. Formed on the surface of copper when ignited. Combines with some of the acids.

Peroxide. Black. Not decomposable by any degree of heat alone, but yields its oxigen very readily to combustible substances heated with it. Soluble in ammonia, producing an intensely blue colour.

Perchloride. Yellow. On the addition of water forms a green solution.

LEAD.

Soft, but not elastic. Very fusible. Not easily attacked by acids, except the nitric. Poisonous.

Protoxide. Yellow. Fusible. Combines with acids.

Deutoxide. Commonly called red lead.

Peroxide. Puce coloured.

The two last give off part of their oxigen at a red heat, and are converted into the protoxide.

CLASS V.

Metals, the oxides of which are reduced to the metallic state by heat alone.

MERCURY.

The only metal that exists in a fluid or melted state at the common temperature of the atmosphere. It requires a cold of 70 degrees below the freezing point of water to render it solid. Boils a little below a red heat. Thirteen times heavier than water.

Protoxide. Black. Easily decomposed. Combines with acids.

Peroxide. Red. Combines with acids, forming salts more acrid and poisonous than those of the protoxide.

Protochloride. Common calomel. Much used in medicine. Insoluble in water.

Perchloride. Corrosive sublimate. A powerful poison. Sparingly soluble in water.

Deutiodide. Of a beautiful red colour, which might be employed in painting, but that it is not permanent.

Cyanuret, or bi-cyanide. Of a disagreeable metallic taste, which continues long. Decomposed by heat, giving off cyanogen. Mercury has a stronger attraction for cyanogen than even the alkalies. Poisonous.

Protosulphuret. Black.

Persulphuret. Red. Common cinnabar, or vermillion.

SILVER.

Remarkable for its whiteness and lustre when polished. Very malleable and ductile. Rather more easily fused than copper.

Oxide. Brown. Its salts are white, and remarkable for turning black by exposure to the light.

Chloride. A white and very insoluble powder, which becomes black by a few minutes exposure to the sunshine. Fusible, and forming a horny looking mass on cooling; hence it has been called *horn silver*.

GOLD.

The most ductile and malleable of all the metals. Soft when pure. Fusible at a very strong red or a white heat. Unalterable by air, moisture, or heat. Insoluble in acids, except the nitromuriatic.

Oxides. Not thoroughly understood. They do not combine with acids.

Chlorides. Yellow or brown. Remarkable for the facility with which the gold is reduced to the metallic state.

PLATINUM.

The heaviest body known. Ductile. From its being infusible in our common furnaces, incapable of oxidation by exposure to air or to heat, and not attacked by any acids except the nitromuriatic, it is much used as the material of vessels for chemical purposes.

Perchloride. Brown. Forms an insoluble precipitate with potass, but not with soda.

PALLADIUM.

Somewhat resembles platinum; but is harder, about half as heavy, and more easily attacked by the acids.

RHODIUM.

Brittle. Very hard. Difficult of fusion. When pure, not soluble in any of the acids; but soluble in them when alloyed. Its salts are mostly red or yellow.

IRIDIUM.

The most infusible of the metals. Scarcely soluble in acids. Very hard.

OSMIUM.

Very infusible.

Oxide. Volatile, and possessing a peculiar pungent smell.

ALLOYS AND AMALGAMS.

Combinations of metals with one another are called ALLOYS. When mercury is combined with other metals, the alloy is called an AMALGAM.

An amalgam of tin and mercury, is used for silvering looking glasses. Gold and silver combine very readily with mercury.

An alloy of tin, lead, and bismuth, in proper proportions, may be melted in boiling water.

Copper and tin, produce a very hard and sonorous alloy. In different proportions, they form bell metal, cannon metal, bronze, &c.

Copper and zinc. Common brass.

Nickle, with zinc, copper, &c. Imitations of silver.

Arsenic alloyed with other metals generally renders them brittle.

Alloys of copper with gold and silver are used in jewellery, and for coin. The copper adds to the hardness of gold and silver, which would be too soft for these purposes, if pure.

SALTS.

The following are a few of the most remarkable.

Sulphate of baryta. Heavy. One of the most insoluble of the salts. When mixed with charcoal, and heated to redness, it is converted into sulphuret of barium. A similar change is produced in other sulphates by the same process.

Sulphate of lime. Gypsum, or alabaster, or plaster of Paris.

Sulphate of magnesia. Epsom salts.

Nitrate of potass. Nitre. Gives off oxigen when heated. With combustible matters, it forms explosive mixtures, of which gunpowder is one.

Nitrate of ammonia. Converted by heat into protoxide of nitrogen and water.

Nitrate of silver. Lunar caustic.

Chlorate of potass. When heated, gives off oxigen, purer and more abundantly than nitre. Forms similar, but more powerful explosive mixtures.

Ammoniaco-phosphate of soda. Microcosmic salt. By heat loses its ammonia, and becomes a bi-phosphate of soda. It is much used as a flux with the blow-pipe.

Phosphate of lime. Insoluble. Bones, when burnt to whiteness, consist almost entirely of this salt.

Borate of soda. Borax.

Carbonate of potass. Deliquescent. Obtained from burnt wood, or land vegetables. Deprived of its carbonic acid by lime, forming caustic potass.

Carbonate of soda. Efflorescent. Obtained from burnt sea weeds.

Carbonate of ammonia. Pungent smell. Produced by the decomposition of animal matter by heat.

Carbonate of lime. Chalk, marble, and limestone.

Hydrosulphate of ammonia. One of the most volatile of the salts, subliming with the warmth of the hand. Its solution is much used as a test, and precipitates most metals (but not the alkaline metals and earths), from their solutions.

Ferrocyanate of potass. Produces beautiful lemon coloured crystals. Used as a test. Commonly called prussiate of potass.

Muriates. The name formerly applied to the chlorides.

ORGANIC CHEMISTRY.

There are a large number of substances of vegetable and animal origin, of which a few only can be mentioned in this work. Those of *vegetable* origin are mostly composed of carbon, hydrogen, and oxigen; and a few of them contain nitrogen. Those of *animal* origin contain nitrogen more generally and more abundantly. These substances are complicated in their composition, and cannot be produced synthetically by the direct artificial combination of their elements.

VEGETABLE ACIDS.

Acetic acid. The acid of vinegar. Produced also by the distillation of wood.

Oxalic acid. Produced by the action of nitric acid on sugar, and on many other substances.

Tartaric acid. The acid of common cream of tartar, which is a bi-tartrate of potass.

Citric acid. Extracted from lemon juice.

Gallic acid. From gall nuts.

Malic acid. From sour apples, and from unripe fruits.

VEGETABLE ALKALIES.

Morphia, Quinine, Strychnia, Emetine, Veratria, &c. The active ingredients of various drugs, and many of them highly poisonous. They combine with acids.

VEGETABLE SUBSTANCES, NEITHER ACID NOR ALKALINE.

Fixed oils. Insoluble in water and alcohol. Incapable of being distilled without partial or complete decomposition. Such are olive oil, linseed oil, almond oil, &c. They combine with fixed alkalies, forming soaps.

Volatile, or essential oils. Soluble in alcohol, and slightly so in water. Possessing a strong smell, and capable of being distilled without decomposition. Such are oil of turpentine, peppermint, &c.

Camphor. In its properties allied to the volatile oils.

Resins. Soluble in alcohol, some of them forming varnishes.

Gums. Soluble in water, but not in alcohol.

Alcohol. Lighter and more volatile than water.

Æther. Still lighter and more volatile, boiling at 98 Farenheit.

Sugar, and other Saccharine Matter, Starch, &c.

Colouring matters. Many of these may be precipitated and rendered insoluble by metallic solutions, as that of cochineal by muriate of tin, &c.

Tannin. The most important ingredient in gall nuts, in the oak bark used for tanning leather, and in other astringent vegetable substances.

ANIMAL SUBSTANCES.

Fibrin. The insoluble portion of muscular fibres, or the lean of meat.

Albumen. White of egg, is nearly pure albumen. It coagulates at a heat below that of boiling water.

Gelatine. Exists almost pure in isinglass, glue, &c. It is precipitated by tannin forming an insoluble compound with it. Skins or hides are mostly gelatine, and are rendered less susceptible of the action of wet, or of the weather, by the process of tanning.

PART III.

A Series of Experiments to illustrate the Principles of the Science, and interesting either from the striking Appearances produced, or from their Reference to some Phenomenon of Nature, or some important Art of Life. With observations on the Doctrine of Definite Proportion, Specific Gravities, &c.

CALORIC, OR HEAT.

By CALORIC is meant, in the language of chemistry, that principle on which the phenomena of heat depend. It has a constant tendency to pass from one body to another until both have the same temperature, or until an equilibrium of temperature is established. When transmitted *along the substance* of a body, it is said to be *conducted;* thus, when one end of a silver spoon is held over a candle, the heat is speedily conducted to the fingers at the other end. When it passes directly *in straight lines* from one body to another, it is said to be *radiated:* thus, if a red-hot poker be held near the face, the heat will be radiated from it to the skin, and the radiation takes place only in straight lines, for if the hand be held between the heated body and the face, the heat will not pass round it to reach the face.

Different bodies are said to possess different *capacities for caloric:* that is, they may be at the same temperature, and yet contain very different *quantities* of heat. For instance, if a piece of copper and a piece of brick, each weighing the same, be heated together in an oven, and then immersed separately in equal quantities of cold water, the brick will be found to have communicated to the water more heat than the copper, or to have raised its temperature to a higher point.

The *quantity* of caloric thus contained in a substance, and not indicated by its temperature, is called its *specific caloric*, or its *latent heat.* Liquids generally contain more latent heat than solids, and gases far more than liquids. See *Exp.* 69.

The TEMPERATURE of a body depends *on the quantity of heat it actually contains, in proportion to its capacity* for heat; and when the disproportion is very great, the body is intensely hot or cold, and the caloric has a tendency to pass to or from it, from or to surrounding bodies. Temperature is measured by the thermometer.

Heat *expands* nearly all bodies, while cold *contracts* their dimensions. A pint of cold water, therefore, weighs more than a pint of the same liquid boiling hot. Liquids are expanded by heat more than solids, and gases far more than either.

Heat converts solids into liquids, and both of these into the aëriform or gaseous state. There is reason to believe that *all* substances would be subject to these changes, if we possessed the means of producing far higher degrees of heat than we can at present command. Different substances are fusible, or vaporizable at very different temperatures. For instance, a piece of tin foil may be melted over the candle, while platina foil is not fusible in the most powerful ordinary furnace. Carbon, or charcoal, has never yet been either vaporized or fused.

HEAT CONDUCTED.

Exp. 62.—Take a piece of copper, and another of iron wire of equal length and size: heat one end of each at the same time in the same flame, and observe that the heat is transmitted or conducted to the fingers, holding the wires at the other end, more rapidly in the copper than in the iron. Some metals, as silver, gold, and copper, are better conductors of heat than others, as iron, platina, &c., and metals generally, conduct better than most other bodies, such as glass, wood, and especially wool and furs. For this reason the handle of a metal tea-pot is made of wood. We can hold a hot body in a piece of flannel; and we clothe in wool, because it transmits the heat to or from the body so slowly. During a hard frost, a piece of metal may feel colder to the hand than a piece of wood, because the former conducts the heat away from the skin more rapidly than the latter; although both would indicate the same temperature by the thermometer.

Exp. 63.—Paste some thick wires of different metals, as copper, iron, &c., between two pieces of white paper in a diverging direction, so that both or all the metals at one end are brought and twisted together, projecting an inch or two beyond the border of the papers. Then brush some sympathetic ink on the paper, over each of the wires. When all is quite dry, heat the twisted end of the metals in the spirit lamp. Green lines will creep along the paper over the wires more or less rapidly, according to the conducting power of each metal.

Exp. 64.—Fill a long thin glass tube with water, hold it obliquely, and apply the heat of the spirit lamp near the upper surface of the water. It will soon boil at this part, though the temperature be scarcely raised at the bottom. It may even remain frozen at the bottom, and boil at the surface.

Exp. 65.—Heat the bottom of the same tube: it will boil at the surface as soon as where the heat is applied.

The two preceding experiments prove that water is not a good conductor of heat. The transmission of the caloric in the present instance is mainly owing to the causes explained in the following experiment:

Exp. 66.—Fill a flask or other glass vessel with water, containing a little coarsely powdered amber, and heat it at the bottom towards one side. The heated particles of water will immediately ascend towards the surface, while the colder ones descend to take their place, and again to ascend in their turn. Continued currents are thus produced from the bottom to the surface, distributing the heat equally throughout the liquid; and these currents are rendered visible by the amber. Fluids, therefore, *carry rather than conduct* heat. If a boiler, or an urn, be heated at the side, the water in it may exhibit the phenomena of ebullition at its surface, and yet the temperature of what is drawn off from the tap at the bottom may be much below the boiling point.

In like manner the heat of the sun in the tropical regions of the earth produces continual currents in the ocean, from the equator to the poles; thus tending to equalize the temperature of the great mass of waters, and through their medium, of the earth generally. The winds are to be accounted for on a similar principle.

HEAT RADIATED, REFLECTED, AND ABSORBED.

Exp. 67.—Provide two similar tin canisters; blacken the outside of one of them, and preserve the other very bright. On filling them both at the same time with boiling water, the bright one will be found to cool much more slowly than the other. The rapidity with which bodies radiate heat depends on the nature of their surface. The brighter and whiter the surface, the more favourable it is to the *reflection* of heat; but the less favourable to *radiation*. For this reason a bright silver tea-pot draws the strength out of tea better than one of black earthenware; for independent of its being of less substance, and having a smaller capacity for caloric, it dissipates the heat of the water, by radiation, more slowly.

Exp. 68.—Lay some shreds of cloth of different colours, white, black, red, &c., upon the surface of the snow, where the sun can shine upon them. The darker colours will absorb more of the sun's rays, and sink deeper into the snow thawing under them than the lighter ones. Colour has a considerable influence on the absorption, as well as on the radiation and reflection of heat. A black dress is known to be warmer than a white one in the sunshine, because it *absorbs more* heat; but the latter may be warmer at another time, because it *radiates less* heat from the body.

LATENT HEAT.

Exp. 69.—Ascertain the temperature of some ice or snow, which will be 32° by the thermometer. Pour a little boiling water upon it, but not sufficient to melt the whole. After a little while, the temperature will be found still at 32°, shewing that a quantity of heat must have disappeared or become latent, because water has a greater capacity for heat than ice. If a piece of red hot iron were immersed in boiling water, the temperature of which is 212°, a portion of the water would immediately be converted into vapour; but the temperature of the whole would still remain at 212°, because steam has a greater capacity for heat than water. For the same reason, steam, though only at 212°, will quickly raise cold water to the same temperature with itself, its caloric being converted from *latent* into *sensible* heat.

If cold water be made very rapidly to absorb cold muriatic acid gas, it will become quite hot, from the caloric previously latent in the gas.

FREEZING MIXTURES.

Exp. 70.—Mix together equal parts of common salt and snow, or pounded ice. This is a powerful freezing mixture, and will sink the thermometer to about 0, (Zero) or more than 30 degrees below the freezing point of water. A little water in a test tube, immersed in this mixture, will speedily be frozen. Here, the mixture, by liquefying, acquires a greater capacity for heat, and absorbs it from the surrounding bodies. By a mixture of snow, and crystalized muriate of lime, a more intense degree of cold may be produced, capable of solidifying mercury, which requires 71 degrees below the freezing point of water. Spirits of wine cannot be frozen by any known degree of cold, and is therefore adapted for the construction of thermometers for measuring the lower temperatures.

Exp. 71.—Wrap a little fine muslin doubled round the bulb of a thermometer, and wet it with sulphuric æther. The instrument will indicate a considerable reduction of temperature, from the rapid evaporation of the æther, which, by assuming the aëriform state, requires more latent caloric, and absorbs it from surrounding bodies. A little water in a test tube may even be frozen by this means, (or more easily with sulphuret of carbon,) if the evaporation be promoted by gentle blowing with a pair of bellows.

EXPANSION BY HEAT.

Exp. 72.—Apply warmth to a retort, flask, or any similar vessel, of which the beak is immersed in water. Bubbles will escape from the expansion of the air within; but on cooling, the water will ascend in the neck of the vessel, from the air again contracting its dimensions. The action of the thermometer is upon this principle.

Exp. 73.—Take a piece of thick and very long straight copper wire, a foot or more in length, and bind it side by side with a similar piece of iron wire, by means of some fine copper wire, very tightly at one end, and loosely at the other. File both ends so that they may be even, and the two wires exactly of the same length. Heat them powerfully with a spirit lamp, when one of the wires will be observed (at the loose end) to have become perceptibly longer than the other. They will become even again on cooling. Different solids and liquids are thus unequally expanded by the same degrees of heat.

Harrison's compensation pendulum, and Arnold's chronometer, are ingenious applications of this principle, of immense importance to navigators.

Exp. 74.—Expose a bottle filled with water and tightly corked to the open air in a hard frost. The freezing of the water will burst the glass. Water is a partial exception to the general laws of expansion by heat. Above 40° it expands, like other bodies by heat; but below that temperature down to the freezing point it expands by cold, and still more on its conversion into ice, which therefore floats on water. Other substances, as bismuth, antimony, and cast iron expand at the instant of solidification. These metals are therefore capable of taking more correctly the impressions of the moulds in which they are cast, than are those metals which contract on solidification. Antimony for this reason enters into the alloy of which printer's type is made.

ELASTIC FORCE OF VAPOUR.

Exp. 75.—Hold the thumb firmly on the mouth of a long test tube containing some water, and make this boil over a spirit lamp. A strong pressure will be felt against the thumb, which if the heat be increased, it will be unable long to resist. Were a cork inserted instead of the thumb, it would either be driven out with force, or the tube would burst. If, retaining the thumb in this position, the tube be now plunged into cold water, a feeling of suction will be perceived against it. If some tow be wrapped round the end of a piece of stick, and well greased with tallow, so as to fit with moderate tightness into the tube, as a piston in a syringe, it will be raised by applying heat to boil the water; again depressed by immersion in cold water, and so on alternately. This may serve to illustrate the principle of the steam engine.

BOILING POINTS OF LIQUIDS.

Exp. 76.—The point at which a liquid boils depends considerably on the *pressure* to which it is subjected, and the resistance thus offered to the expansion of its vapour. Cause water to boil as in the last experiment, with the thumb held firmly on the mouth of the vessel. The ebullition or boiling will be thus impeded, but will take place rapidly on the removal of the thumb. By pouring cold water over the upper part of the tube, (retaining the thumb over its mouth,) so as to condense the vapour formed in it, and thereby diminish the pressure, the water will boil, apparently from the application of cold. If the atmospheric pressure be altogether removed, as in the exhausted receiver of an air-pump, water will boil below 100°, a heat little exceeding the ordinary temperature of the human body. Under the same circumstances, æther will boil much below the point at which water freezes. Under increased pressure, water may be heated to 500 or 600 without boiling; but then its expansive force is tremendously great, and would burst any vessel not exceedingly strong. Papin's digester is a vessel of this kind.

When some of the common gases, such as carbonic acid, are condensed into a liquid state, they possess at the natural temperature of the air, the same powerful expansive force as water at very high temperatures, and experiments with them are consequently dangerous.

OXIGEN.

Exp. 77.—Oxigen gas may be obtained by exposing chlorate of potass to heat in a small glass retort, or in a tube retort. The heat of an argand or spirit lamp will be sufficient, and a green glass retort is preferable, as it resists the requisite heat without softening and blowing out. The chlorate will first melt, and soon after give off the gas, which may be collected over water.

The least expensive mode of obtaining this gas in large quantity, but not very pure, is by exposing oxide of manganese to a red heat in an iron bottle.

For the glass retort may be substituted a Florence flask, having a tube fitted to it by means of a bored cork; and with care it may be collected in 8oz. or 12oz. white glass bottles, instead of air jars. In these it may be secured for some time by means of corks, and the bottles may be known to be full of gas when a little chip of deal wood, lighted and blown out, being introduced but just inside the neck, bursts into flame. (See *Exp.* 43.) By a little ingenuity in contrivance, a number of the following experiments with the gases may be performed on a small scale with the apparatus in the small chemical chests, Nos. 2 and 3, and the addition of a few common articles which may be obtained in any town.

Exp. 78.—Introduce a wax taper which has just been blown out, while the wick still remains red hot, into a jar of oxigen gas. It will be instantly re-lighted and burn brilliantly. The taper is best attached to a piece of bent wire. It is the oxigen gas contained in the atmosphere in the proportion of about one-fifth, which supports combustion under ordinary circumstances; and in the pure gas itself the combustion is five times more energetic.

Exp. 79.—Coil a piece of harpsichord steel wire into a spiral form, dip the end of it in melted sulphur, light it, and introduce it into a jar of oxigen gas. The wire will burn in the most splendid manner, throwing out brilliant sparks. This experiment, when well executed, produces a beautiful effect.

Exp. 80.—Put a little phosphorus dried on blotting paper into a copper deflagrating ladle, and having lighted it by means of a hot wire, introduce it quickly into a jar of oxigen gas. It will burn with a dazzling light, only comparable to that of the sun.

Phosphoric acid is here produced by the combination of the oxigen with the phosphorus, and this acid will be deposited on the sides of the jar.

If not better provided, the reader may perform each of the three last experiments in a large flint glass bottle.

NITROGEN.

Exp. 81.—Introduce a lighted taper, or some burning phosphorus, into a jar containing nitrogen gas, procured as in *Exp.* 42. Either of these will be extinguished.

PROTOXIDE OF NITROGEN.

Exp. 82.—This may be obtained by heating nitrate of ammonia in a retort, and collecting the gas over warm water. Care is required not to immerse the beak of the retort in water until the salt is perfectly dry, otherwise the water may rise in its neck (from absorption of the vapour) and spoil the experiment.

This is the gas, which when inhaled into the lungs, produces such singular inebriating effects; an experiment which beginners are recommended not to attempt.

DEUTOXIDE OF NITROGEN, NITROUS AND NITRIC ACIDS.

Exp. 83.—Pour nitric acid, diluted with an equal quantity of water on some copper clippings or wire in a retort or flask, to which a tube is adapted, and apply a gentle heat when the effervescence slackens. The *deutoxide of nitrogen* or *nitrous gas* thus evolved may be collected over water.

Exp. 84.—Fill a jar with deutoxide of nitrogen gas which is colourless, and invert it in the air. Red or orange coloured fumes will be immediately produced, with a suffocating smell. The gas here combines with an additional quantity of oxigen, which it abstracts from the air, forming *nitrous acid*, to which the colour is owing.

Exp. 85.—Transfer deutoxide of nitrogen into a jar, half filled with oxigen gas over water. Deep red fumes of nitrous acid will result, and be absorbed by the water which will rise in the jar.

Exp. 86.—Pour *nitric acid*, mixed with one-fifth as much sulphuric acid (both very strong) upon oil of turpentine in a large gallipot. A violent action will immediately ensue, and the turpentine will burst into flame. This experiment should be performed in the open air, and the phial from which the acid is poured should be tied to the end of a long stick, that the operator may avoid the flame and splashing produced.

HYDROGEN.

Exp. 87.—Fill with hydrogen gas (procured as in *Exp.* 36, 37, 38) a bladder fitted with a stop-cock and brass tobacco pipe. With some soap lather, by pressure on the bladder, blow soap bubbles. They will ascend rapidly in the air from the lightness of the gas. If a turkey's crop be filled with this gas, and securely tied, it will ascend in the room and remain against the ceiling for a considerable time. Balloons are filled with hydrogen.

Exp. 88.—Fill a bladder with a mixture of one part by measure of oxigen and two of hydrogen gases, and blow soap bubbles as in the last experiment. If a lighted piece of paper be applied to one of these bubbles, it will explode with a loud report. Care must be taken not to apply the light until the bubble is entirely detached from the tobacco pipe, as the fire would easily communicate with the bladder, and produce disagreeable or dangerous consequences. The explosion results from the instantaneous combustion of every particle of the gas at once.

Exp. 89.—Tie into the neck of a bladder a piece of glass tube of large calibre, into which a cork can be securely fitted. Pass two wires through the cork, at as great a distance as possible from each other, and bend the ends of them after they have entered the bladder, so that they may almost touch, within one-eighth of an inch. Fill the bladder with a mixture of two measures of hydrogen and one of oxigen gas, and having fitted the cork securely, without deranging the position of the wires, suspend it on a tree, or where its explosion can do no harm, on a dark night. Let the outer ends of the wires communicate by means of other wires with the ground. Then pass an electric spark, or if necessary, a shock from a Leyden phial, through the wires. The gases will explode with great violence, causing a beautiful flash of light.

Exp. 90.—Apply a piece of spongy platina to the jet of gas produced as in *Exp.* 36. It will quickly inflame it.

This curious property of spongy platina has not been quite satisfactorily accounted for. It is applied to the production of instantaneous light.

Exp. 91.—If the mixed gases described in *Exp.* 88, be made to issue from a bladder through a Hemming's safety jet, or oxyhydrogen blow-pipe, and inflamed at its orifice, the most intense heat will be produced, capable of instantly melting platina and other very infusible substances. Iron melts in it like wax, at the same time burning with great brilliancy. A piece of quicklime, or chalk heated in this jet of flame, produces the most dazzling and intense light that can be obtained by artificial means, and this has recently been applied in illuminating minute objects for the microscope. Lieut. Drummond proposed its introduction in light-houses, and in some of his experiments it was rendered visible at a distance of more than 70 miles.

The experiments with the oxyhydrogen blow-pipe are among the most striking which chemistry can offer. (See *Frontispiece*, fig. 1.)

Exp. 92.—Hold a piece of glass tube from an inch to an inch and a half in diameter, and 12 or 18 inches long, perpendicularly over a small inflamed jet of hydrogen gas, (see *Exp.* 36) so that the flame may be introduced an inch or two into the tube. A loud and singular howling sound will be produced, and water will be deposited against the inside of the tube, being formed by the combination of the hydrogen with the oxigen of the air.

CARBON.

Exp. 93.—Heat a piece of charcoal (made from box or any similar hard wood) to redness, in a crucible filled with sand. While still warm, introduce pieces of it into narrow jars or wide tubes containing different gases, as ammonia, carbonic acid, oxigen, &c., standing over mercury. In the course of a day or two, the charcoal will have absorbed more or less of each gas, the ammonia being absorbed in the greatest, and the oxigen in the least proportion.

Exp. 94.—Mix some fœtid ditch-water, or water containing vegetable or animal colouring matter, with animal charcoal. After some hours or days, they will have entirely lost their smell and colour. Animal charcoal is obtained by heating bones, or dried blood to redness out of contact with the air, and afterwards washing it with water to separate the soluble substances it contains. It is much used for purification in chemistry, and especially in the preparation of the vegetable alkalies, &c., for medicinal use.

CARBONIC ACID GAS.

Exp. 95.—Pour diluted muriatic acid on white marble in small lumps, and collect the gas evolved, as in *Exp.* 32, without employing a pneumatic trough. The aid of heat is not required, and for the following experiments the vessels should be dry.

Exp. 96.—Introduce a taper, or even a bit of lighted phosphorus into a jar, tumbler, or deep ale-glass, filled with carbonic acid gas. It will be immediately extinguished.

Exp. 97.—Fill a jug with carbonic acid gas, and pour it, as if it were water, over a lighted candle. The candle will be extinguished as though by an invisible influence.

Exp. 98.—Fill a clean and very dry Florence flask with carbonic acid gas, introduce a piece of potassium, insert a cork loosely, and apply a gentle heat with a spirit lamp against the potassium until it takes fire. The flask will probably be broken by the combustion, and after the experiment a quantity of black matter, resembling charcoal, will be found. This is in fact carbon, from the decomposition of the carbonic acid; the potassium having so powerful an attraction for oxigen as to abstract it, with the phenomena of combustion, even from this gas, in which no ordinary substance will burn.

Exp. 99.—Blow soap bubbles with carbonic acid gas; they will descend as rapidly as those formed with hydrogen ascended.

Exp. 100.—Put some lime water, or baryta water, into a test tube, and blow through it for some minutes from the lungs, by means of a glass tube. It will become milky, from the carbonic acid which is generated in the lungs of all animals, combining with the lime or baryta, and forming an insoluble carbonate.

Exp. 101.—Expose a particle of chalk, or marble, (carbonate of lime) for some time to the utmost heat of the blow-pipe. It will be converted into quicklime. If weighed before and after the experiment, it will be found to have diminished from the expulsion of the carbonic acid gas.

Exp. 102.—Expose lime or baryta water to the air; a thin pellicle will form on its surface, which becoming thicker, will fall to the bottom, and be succeeded by others, until after many days the liquid will have entirely lost its caustic taste. This arises from the absorption of carbonic acid gas, which always exists in the air; the pellicle being an insoluble carbonate of the earth. The gas may be driven off with effervescence from the subsided pellicles by muriatic acid.

CYANOGEN.

Exp. 103.—Put some bi-cyanide, or cyanuret of mercury in powder into a test tube, to which is adapted, by means of a bored cork, a small piece of glass tube, drawn out at the end. Heat the bicyanide with a spirit lamp. Some metallic mercury will be reduced, and cyanogen gas will issue through the tube. If lighted, it will burn with a beautiful carmine coloured flame.

CARBURETTED HYDROGEN.

Exp. 104.—Fill the bowl of a tobacco pipe with common small coal: cover it over with a little clay, and when dry, introduce it into a common fire. In a few minutes, carburetted hydrogen gas will issue from the end of the pipe, where it may be lighted; illustrating the manner in which common coal gas is produced. The gas is, at first, very impure, and at the manufactory, in order to render it fit for use, it is purified by being washed with lime water. This abstracts the sulphuretted hydrogen and carbonic acid contained in it.

Exp. 105.—Pour four parts by weight, or three by measure, of sulphuric acid into a retort, containing one part of alcohol. Apply heat immediately, and after a little time per-carburetted hydrogen, or olefient gas, will be disengaged, and may be collected over water. This burns with a very luminous white flame, and the more of it there is contained in the coal gas, the greater is the light it gives.

Exp. 106.—Mix olefient gas with four or five times its bulk of oxigen gas: blow soap bubbles with the mixture: carefully apply a lighted paper to them, when the explosion produced will be far more powerful than in *Exp.* 88. If instead of oxigen gas, the olefient gas be mixed with ten times its own measure of common air, a less powerful explosive mixture will be formed.

If common coal gas be allowed to escape in a close room, it forms a mixture with the air which will explode the instant a candle approaches it, and has on many occasions produced the most serious accidents.

Exp. 107.—Hold a piece of fine wire gauze across the flame of a candle or gas light. The combustion above the gauze will be intercepted, the flame being unable to pass through its minute apertures, owing to the cooling influence of the wire which reduces the temperature of the gas below the point at which it is capable of inflaming. The most important application of this circumstance is in the celebrated miners' *safety lamp* of Sir Humphrey Davy. This consists of a lantern of wire gauze, in which the lamp is enclosed, allowing the light to penetrate it, and admitting a free supply of air: but rendering it impossible for the flame within to set fire to the inflammable gas (called fire-damp) so often mixed with the atmosphere of a coal mine, and the subterranean explosion of which has too frequently caused dreadful destruction of life among the workmen.

Exp. 108.—Pour a little of the volatile oil of Indian-rubber, (caoutchoucine) into a jar, tumbler, or any deep glass. It will speedily evaporate from the bottom, filling the jar with invisible vapour. This vapour, like a heavy gas, may be poured from one vessel into another. It is highly inflammable, and may be lighted in the jar. This experiment may also be made with sulphuret of carbon, or sulphuric æther, having first slightly warmed the vessel.

SULPHUROUS ACID.

Exp. 109.—This gas, (which is the product of the combustion of sulphur in air or oxigen gas,) may be obtained by heating mercury with two or three times its weight of sulphuric acid. It has a very suffocating smell, (that of burned brimstone,) and cannot be collected over water.

Exp. 110.—Fill a stoppered bottle with sulphurous acid gas, and introduce into it some pieces of coloured linen previously moistened, or a red rose. The colour of the linen will be discharged, and the red rose will become a white one.

The fumes of burnt brimstone are sometimes dishonestly applied to the purpose of whitening the last year's walnuts, and thus giving them the appearance of fresh ones. This gas is occasionally employed in bleaching.

SULPHURETTED HYDROGEN.

Exp. 111.—Add sulphuric acid, diluted with five or six times as much water, to sulphuret of iron. The gas will be evolved without the aid of heat. It possesses a very fœtid smell, and none of it should be allowed to escape in a room. Fresh white paint would be blackened by it. This gas is much used in experiments with the metals, &c.

PHOSPHORUS.

Great caution must be observed in the management of this very inflammable substance. It should be cut under water, and never held in the fingers.

Exp. 112.—Trace figures on paper with phosphorus stuck in the end of a quill. These will glow in the dark.

Exp. 113.—Pour some phosphorized æther on the surface of warm water. It will assume the appearance of liquid fire.

PHOSPHURETTED HYDROGEN.

Exp. 114.—Put a few pieces of phosphuret of lime into a glass of water. Bubbles of phosphuretted hydrogen gas will be formed, which on rising to the surface, will take fire spontaneously with a snapping noise, producing, if the air be still, beautiful ringlets of smoke. Should the phosphuret not be fresh, it may be necessary to use warm water, and to promote the effect by adding a little muriatic acid. This experiment should be performed in the open air, on account of the fœtid smell of the gas.

It is said that on the introduction of coal gas in London, some persons, who were interested in opposing it, absurdly caused phosphuret of lime to be dropped here and there in the puddles near the gas-posts to a considerable extent, hoping thereby to prejudice the public with the idea that the smell originated from the coal gas.

CHLORINE.

Exp. 115.—To obtain chlorine gas, mix oxide of manganese in a retort or flask, with muriatic acid diluted with an equal quantity of water, and apply a gentle heat. The gas, which possesses a powerful irritating smell, and a faint yellow colour, will be best collected for common experiments in wide-mouthed stoppered bottles, without a pneumatic trough. It is much heavier than common air.

Exp. 116.—Introduce some wetted pieces of coloured linen into a bottle of chlorine gas; they will speedily lose their colour. Chlorine, in the form of chloride of lime, is much used in bleaching.

Exp. 117.—Expose some tainted meat, fœtid ditch-water, or any other organic matter rendered offensive by decomposition, to chlorine gas. The smell will be completely destroyed. Chlorine appears, in most instances, to render inert the effluvia of putrid and contagious diseases, fevers, &c. The disinfecting solutions of chloride of lime, or soda, are preferable for this purpose, as when exposed to the air they give off the gas slowly and constantly, without causing annoyance by an excessive quantity being disengaged at once, and without risk of interrupting the supply of it.

This property of chlorine, as well as that demonstrated by the last experiment, appear to be owing to its strong attraction for hydrogen, (*Exp.* 118) which it separates from organic colouring matter, and from the invisibly minute particles on which smell and contagion depend, thereby destroying their composition.

When water is present, chlorine acts as a powerful oxidizing agent, by combining with the hydrogen, and setting free the oxigen of the water.

Exp. 118.—Expose a mixture of equal measures of hydrogen and chlorine gases to the daylight for some time in a stoppered, or securely corked bottle. They will combine, forming muriatic acid gas, as may be shewn by the immediate absorption on withdrawing the stopper under water. If exposed to the direct sunshine, the gases will combine with a feeble explosion; an experiment that must not be attempted with the stopper in the bottle.

Exp. 119.—Introduce a bit of phosphorus (dried by suffering it to lie two or three minutes on some blotting paper) into a bottle of chlorine gas. It will take fire spontaneously.

Exp. 120.—Throw some powdered metallic arsenic into a jar or tube, (the deeper the better) filled with chlorine gas. The metal will take fire spontaneously, producing the appearance of a beautiful shower of stars. Copper leaf and some other metals, also take fire spontaneously in this gas.

OXIDE OF CHLORINE, OR EUCHLORINE.

Exp. 121.—Put two or three grains of chlorate of potass, with as much sulphuric acid as will moisten it, into a test tube, and apply an exceedingly gentle heat by merely dipping the tube in warm water. A gas of a deeper yellow colour than chlorine will rise and fill the tube. This is the deutoxide of chlorine. It explodes with extreme violence by a moderate heat, as may be shewn by heating the end of a wire in the candle, and introducing it a little way into the tube.

In experiments of this kind, (which ought to be performed only on a very small scale) it is advisable to wrap a piece of cloth round the glass, to prevent injury if it should be broken.

FIRE UNDER WATER.

Exp. 122.—Having put a tea-spoonful or more of chlorate of potass into a deep ale glass, let it be nearly filled with water, (somewhat warm) and add a few small chips of phosphorus. Then pour strong sulphuric acid through a funnel with a long neck to reach the bottom of the glass, that the acid may act on the chlorate before it becomes too much diluted. Flashes of fire will be seen from the phosphorus, burning in the oxide of chlorine gas, which is evolved under water.

Exp. 123.—Rub together in a mortar eight grains of chlorate of potass, three of sulphur, and two of charcoal. The mixture will explode with a cracking report on brisk friction with the pestle. A chip of phosphorus wrapped with some chlorate of potass in a piece of paper, and struck with a hammer, or flat stone, will detonate powerfully; but the experiment requires caution, as the phosphorus may fly about, and do mischief. The chlorate also forms a detonating mixture with sulphuret of arsenic or antimony.

Until lately, mixtures of this kind were used for the percussion caps of guns; but fulminating mercury has been found more convenient for the purpose.

Exp. 124.—Mix together six parts of chlorate of potass, three of sugar, and one of sulphur. This mixture on being touched with a drop of sulphuric acid, will burst into flame.

The matches for instantaneous light are dipped in a paste made of a similar composition.

The phenomena in this and the preceding experiment are to be explained by the facility with which chlorates part with their oxigen.

IODINE.

Exp. 125.—Iodine is remarkable for the beautiful violet coloured vapour it forms when heated. (See *Exp.* 27). Put a few grains of iodine into a large flask, or flint glass bottle, and warm it before the fire.

Exp. 126.—Bring a bit of phosphorus into contact with iodine in a saucer. It will immediately take fire.

FLUORIC ACID.

Exp. 127.—Mix in a gallipot, or evaporating basin, some fluor spar in fine powder with sulphuric acid, to the consistence of thin paste: cover this with a piece of glass, and apply a gentle heat. Fluoric acid will be disengaged, and corrode the glass.

Etching may be effected on glass, by covering its surface with a thin coat of wax, and then tracing figures or writing through the wax. The acid will act on the glass only where it is exposed by the lines of the tracing; and on warming and wiping off the wax, these will be found corroded more or less deeply.

In making fluoric acid, retorts of lead or silver must be used. Those of glass would be speedily corroded into holes, besides contaminating the product.

METALS AND THEIR COMPOUNDS.

Exp. 128.—Throw a piece of potassium into water or upon a lump of ice. This singular metal will immediately take fire with a violet coloured flame. On afterwards applying a slip of turmeric paper to the water, it will become brown, indicating the production of an alkali, (potass,) by the oxidation of the potassium.

Exp. 129.—Dissolve a few grains of mineral chameleon, (manganate of potass), in a glass of cold water. The solution, at first green, will change to purple, then to red, and after some time, will become colourless. If hot water be used, the changes will be somewhat different, and more rapid.

Exp. 130.—Expose a solution of proto-muriate of iron (which is of a pale green colour), to the air; it will become yellow from the absorption of oxigen, and be converted into a permuriate.

This change may be effected more rapidly by boiling the proto-muriate in a test tube for half a minute with a drop or two of nitric acid.

Exp. 131.—Add tincture of galls to a solution of muriate, or any other salt of iron. It will become intensely black, from the formation of tannate or gallate of iron.

Common *ink* is made by mixing sulphate of iron with infusion of galls; gum arabic being added to prevent the ready subsidence of the black precipitate. The black colour will be destroyed by adding muriatic, oxalic, or any powerful acid, which will decompose the gallate. Ink spots may be taken out of linen by means of acids: but such only should be used for this purpose, as do not destroy the texture of the cloth; as the oxalic, or the tartaric.

Exp. 132.—Add ferrocyanate of potass to a solution of any per-salt of iron; a blue precipitate will result, which is *Prussian blue.* The ferrocyanate added to other metallic solutions, will produce precipitates of different colours.

Exp. 133.—Cause bubbles of sulphuretted hydrogen gas to pass slowly through a solution of permuriate of iron, formed as in *Exp.* 130. A milkiness will be produced, from the deposition of sulphur from the gas, the hydrogen of which combines with part of the oxigen of the iron, reducing it again to a proto-muriate of a green colour.

Exp. 134.—Cause sulphuretted hydrogen gas to pass, in like manner, through solutions of various metals; it will precipitate the greater part of them in the form of sulphurets. With lead, copper, bismuth, silver, and mercury, it will form *black* precipitates; with tin and antimony, *yellow,* &c.

Exp. 135.—Moisten a slip of paper with a solution of sugar of lead, and expose it to sulphuretted hydrogen gas: it will be blackened.

Exp. 136.—Add chromate of potass to solutions of various metals: it will form, with iron, a *brown* precipitate; with acetate of lead, *a yellow*; with nitrate of silver, a *crimson*; and with copper, a *green* precipitate.

Exp. 137.—Add hydriodate of potass, (or iodide of potassium,) to a solution of corrosive sublimate (perchloride of mercury). A beautiful *red* precipitate, iodide of mercury, will be formed.

Exp. 138.—Add a solution of hydriodate of potass to one of acetate of lead. A *yellow* precipitate will be formed. Pour on this a very large quantity of boiling water, as a quart or two. This will re-dissolve the precipitate, the whole of which will be deposited, as the water cools, in the form of small brilliant crystals of iodide of lead, resembling gold.

Exp. 139.—Moisten a piece of paper, or white cloth, with a solution of nitrate of silver, and expose it to the sun's rays. It will speedily acquire a black colour, which will not wash out; exhibiting an instance of the effect of light, in influencing chemical changes.

The indelible ink, for marking linen, is made with nitrate of silver.

Exp. 140.—Add ammonia to a solution of copper. It will acquire a beautiful *blue* colour, which is so intense, that by means of ammonia we may ascertain the presence of copper, when suspected in pickles, and other articles of food prepared in copper vessels.

Exp. 141.—Immerse a rod or plate of copper in a solution of nitrate of silver. The silver will be thrown down in the form of a metallic powder, which may be melted on charcoal by the blow-pipe; and the copper will take its place in the solution, which will thereby acquire a *blue* colour. A rod of zinc will again throw down the copper in the metallic state and the solution will become *colourless*, containing only nitrate of zinc.

Exp. 142.—Suspend a piece of zinc in a large bottle, containing a solution of acetate of lead. The lead will be deposited around the zinc in a beautiful arborescent form which has received the name of the *lead tree.*

Exp. 143.—Spread some powdered nitrate of copper on tin foil, sprinkle it with water, and wrap it up as closely and quickly as possible. Intense action will be produced, with red fumes, and sometimes, sparks of combustion.

Exp. 144.—Lay a drop of diluted nitric acid on a surface of bright steel, and another on common iron, (not cast iron). The acid will leave a black spot on the steel (from the carbon which it contains being separated); but not on the iron. The two metals may thus be easily distinguished from each other.

SYMPATHETIC INKS. COLOURED FLAMES.

Exp. 145.—With a clean pen write on paper with a solution of muriate of cobalt, so diluted with water that the writing when dry may be invisible. On gently warming the paper, the writing will appear of a *blue* or *greenish* colour, which will disappear again soon after cooling.

Exp. 146.—A solution of muriate of copper in like manner forms a *yellow* sympathetic ink; and acetate of cobalt a rose or *purple.* If a landscape be drawn representing in its natural state a winter scene, the paper being overlaid in the places where the foliage should be with the *green* sympathetic ink, then on very gently warming the drawing, it will represent summer. Sky and water may be represented with the *blue*, and standing corn, or the thatch of cottages, with the *yellow* sympathetic ink.*

Exp. 147.—Draw or write on paper, with a weak solution of iron or copper, &c. The lines will be invisible, but may be made to appear on brushing them over with diluted tincture of galls, or solution of ferrocyanate (prussiate) of potass, &c. The colours will vary according to the solutions used.

Exp. 148.—Dry some common salt at a low red heat: then moisten it with strong spirits of wine in a saucer, and set it on fire. A *yellow* flame will be produced, and if the other lights in the room be removed, the countenances of those present will assume a livid, ghastly hue.

Exp. 149.—Moisten dried nitrate of strontia with spirits of wine: it will burn with a *carmine coloured* flame, shedding a beautiful tint on surrounding objects.

Exp. 150.—Burn alcohol over any salt of copper in like manner: it will produce a *green* flame. Pure baryta will communicate to the flame of alcohol a brilliant *yellow;* muriate of magnesia, an *orange colour;* boracic acid a *green*, &c.

Some of these substances are employed by firework makers, to colour the stars of skyrockets, &c.

THE ART OF DYEING, CALICO PRINTING, ETC.

Exp. 151.—Wet a piece of white calico with a solution of muriate of iron, and when dry, draw lines or a border upon it with strong lemon juice, and suffer this also to dry. Then rinse it in cold water, and immerse it in tincture, or infusion of galls. The lines or border will remain *white*, while the rest of the cloth will be dyed of a *black* or *slate* colour.

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* G. W.'s Sympathetic Landscapes, recently published by Mr. Morgan of Judd Street, and sold in many print shops, exhibit this curious transformation in much perfection. If the inks are not properly prepared and neutral, the paper will be stained and corroded, and will not again become colourless on cooling.

To the explanation in *Exp.* 131 it is only necessary to add, that in dyeing cloth the precipitation is made in the substance or pores of the stuff itself, so that it cannot afterwards be washed out. The liquid with which the cloth is impregnated before dyeing is called the *mordaunt;* because, by forming an insoluble precipitate, it bites or holds the colour.

Exp. 152.—Steep the calico impregnated with muriate of iron in a very weak solution of potass. It will acquire a *buff or nankeen* colour. Here a peroxide of iron is formed in the pores of the cloth. *Iron moulds* are produced by the same cause.

Exp. 153.—Substitute a solution of ferrocyanate of potass for the tincture of galls. The calico will be dyed *blue,* from the formation of Prussian blue in its pores. A company has recently been established for dyeing blues on this principle; and it is expected in a great measure to supersede the use of indigo.

Exp. 154.—Employ a solution of muriate of tin as the mordaunt, and dye in a decoction made by boiling Brazil and peach-wood or powdered cochineal in water. The calico will be dyed *red.*

Colours produced with muriate of tin are very bright at first, but generally *fugitive:* that is, they either wash out easily, or are deteriorated by exposure to the air. Colours that withstand these trials are said to be *fixed.*

Exp. 155.—Employ a solution of acetate of alumina as the mordaunt, and a decoction of quercitron bark as the dye. A *yellow* colour will result.

Exp. 156.—Dip pieces of coloured cloth in the solution of chloride of lime: they will speedily lose their colour. This solution is called by manufacturers the *bleaching liquid.*

The chemical part of calico printing is similar to that of dyeing. The figures are stamped on the cloth, either with the mordaunt, or with the substance that is to discharge the colour, by means of wooden blocks, or by passing them between copper cylinders bearing the impressions.

CHEMICAL ANALYSIS. TESTS OR RE-AGENTS.

ANALYSIS is of two kinds.

1st. *Qualitative analysis,* which examines the nature of the elements which any compound substance may contain. Tests are the agents used for this purpose, and many of them may be made to afford evidence of a very unequivocal character.

2d. *Quantitative analysis,* which determines the exact proportions in which one or all of the elements of a compound are combined.

Exp. 157.—To a glass of water containing a drop or two of *sulphuric acid,* or a little *sulphate of soda,* add a few drops of the solution of *muriate of baryta.* A white precipitate (sulphate of baryta), will be formed, which cannot be re-dissolved by the addition of any acid.

The soluble salts of baryta, or barytic water, are tests of extreme delicacy, and will detect very minute quantities of sulphuric acid, either free, or in any soluble combination.

The precipitate may be here proved to be a sulphate, by collecting it, mixing it with a fourth as much charcoal, and heating it for a few minutes, in the inner flame of the blow-pipe; after which it will give a smell of sulphuretted hydrogen, on moistening it with diluted muriatic acid.

Exp. 158.—To a glass of water, containing a minute quantity of *muriatic acid,* or common salt, or any soluble compound containing *chlorine,* add *nitrate of silver.* A white precipitate, chloride of silver, will be formed.

Nitrate of silver is a most delicate test for chlorine or muriatic acid.

Exp. 159.—*Tincture of galls* is a test of extreme delicacy for *iron.* A pint of water, containing far less than a grain of any salt of iron, will be perceptibly blackened by it.

Exp. 160.—Dissolve a little *iodine* in spirits of wine, or add a drop of sulphuric acid to hydriodate of potass, and pour this into a solution of common *starch.* It will assume a deep *blue* colour.

Exp. 161.—Rub together a particle of *muriate of ammonia,* and of *potass* or *quicklime;* or put a drop or two of solution of ammonia into a watch glass, and hold close over it the end of a glass rod dipped in *muriatic acid.* White fumes will be perceptible from the union of very minute portions of the two gases, ammonia and muriatic acid, which are thus mutually tests for each other. See *Exp.* 34.

POISONS.

Oxalic acid, which has often been taken by mistake for Epsom salts, from the resemblance of their crystals, is a powerful and rapid poison. It reddens litmus paper, possesses a strong acid taste, and gives a white precipitate with the soluble salts (as the muriate) of lime. By mixture with a sufficient quantity of chalk, or magnesia, it is neutralized, and rendered nearly inert. These, then, are the proper antidotes for the poison, and may save life if given in time. When these are not at hand, if some lime rubbish be dug from the plaster of a wall and administered quickly, it may answer the same end, from the chalk it contains.

Copper, though present in very minute quantity, may be detected by means of ammonia. See *Exp.* **140**; or by immersing in the solution a plate of bright iron, which will, after some time, receive a coating of copper, if there be not too great an excess of acid.

Corrosive sublimate. A solution of caustic lime, potass, or baryta water, or liquid ammonia, will produce an orange coloured precipitate; and hydriodate of potass a brilliant scarlet. The best antidote is the white of eggs, which forms with the sublimate an insoluble and inert compound.

M. Thenard, the celebrated French chemist, while delivering a lecture, once inadvertently swallowed, instead of water, a strong solution of corrosive sublimate. Immediately perceiving the fatal mistake, he sent for the white of eggs; which fortunately was administered to him in five minutes, and prevented any material ill effects from the poison.

LEAD. Hydrosulphate of ammonia, or a current of sulphuretted hydrogen gas, will cause a black precipitate; which, if collected, and heated with a little black flux or charcoal, before the blow-pipe, will give a globule of metallic lead.

ARSENIC. If a liquid, containing arsenic, be mixed with a little muriatic acid, so that it may redden litmus paper, and then be exposed to a current of sulphuretted hydrogen gas, a yellow precipitate (sulphuret of arsenic) will shortly be produced. This is to be collected, washed, boiled with a little nitric acid, and evaporated to dryness in a watch glass. On heating the residue, mixed with charcoal powder, in an arsenic tube, over a spirit lamp, the metal will be sublimed in a metallic state. There is no true antidote for arsenic: the only chance consists in evacuating the stomach and sheathing it from the poison, by the plentiful administration of mucilaginous drinks, milk, &c.

NOMENCLATURE OF MODERN CHEMISTRY.

The terms formerly employed in chemistry were fanciful and unmeaning: but about forty-five years ago, some eminent French chemists, among whom were Lavoisier, Fourcroy, and Berthollet, introduced into the science a new language, in which the name applied to each substance is made to express, as far as possible, its nature and composition. This descriptive nomenclature, modified and improved by the progress of discovery since their time, has tended not a little to the advancement of the science.

According to the modern nomenclature, *carbonate* *of potass* is a combination of *carbonic acid* with *potass. Bi*-carbonate of potass is a similar combination, but containing twice the proportion of carbonic acid. The *sesqui*-carbonate contains one proportion and a half.

The *oxides of copper* are combinations of *copper* with *oxigen;* of these the *prot*-oxide contains a minimum; and the *per*-oxide a maximum proportion of oxigen.

The following are a few examples of the old and new names for the same substances.

Old Names.	*New Names.*
Nitre	Nitrate of Potass.
Salt of Tartar . . .	Carbonate of Potass.
Sugar of Lead . . .	Acetate of Lead.
Oil of Vitriol	Sulphuric Acid.
Fixed Air	Carbonic Acid Gas.
Aquafortis	Nitric Acid.
Spirits of Salt . . .	Muriatic Acid.
White Vitriol	Sulphate of Zinc.
Green Vitriol or Copperas, or Sal Martis . . .	Sulphate of Iron.
Blue Vitriol or Blue Stone .	Sulphate of Copper.
Orpiment	Sulphuret of Arsenic.
Liver of Sulphur . . .	Sulphuret of Potass.
Infernal Stone . . .	Nitrate of Silver.

THEORY OF DEFINITE PROPORTIONS.

Little allusion has been made in the course of this volume to the *proportions* in which elementary substances combine with one another, to form compounds. By *mechanical* mixture, two substances, as sugar and chalk, may be blended together in any proportion; but not so in *chemical* combinations, in which the ingredients (as far as we fully know, for there are some apparent exceptions) invariably combine together in a regular, exact, and definite proportion. Thus, equal parts by measure of chlorine and hydrogen gases will combine together and form muriatic acid gas; but if a little more of either of these elements be added, it will be left out of the combination. If, therefore, three cubic inches of chlorine be mixed over water with *four* cubic inches of hydrogen, and made to combine by exposure to the light, the water absorbing the muriatic acid generated, will leave the superfluous cubic inch of hydrogen in its original state.

Most bodies are, however, capable of combining in several different proportions: but still all of them are definite, and there are no *insensible* gradations from one proportion of combination to another. Thus, carbon and oxigen may be made to combine together in *two* proportions: the one (carbonic oxide) containing by weight 8 parts of oxigen and 6 of carbon; the other (carbonic acid) containing 6 of carbon and 16 of oxigen. But there is no compound of these two elements containing 6 of carbon and 14½ or 15¼ of oxigen. A gas containing any such intermediate proportion would be merely a *mechanical mixture* of the two, from which the carbonic acid might be separated by agitating it with lime water, which would absorb it, and leave the carbonic oxide pure. Some substances combine in *four* or *five* different definite proportions. *Primary* compounds, when combining to form *secondary* compounds, observe the same laws.

When bodies combine in several proportions, it has been found that these proportions bear a simple arithmetical relation to each other, or are simple multiples of some common number, not very remote. The one compound contains twice, or one and a half, three, four, or five times, &c., as much of a particular element as the other. Thus, in the last instance referred to, the proportion of oxigen in carbonic *acid* is exactly double of that in carbonic *oxide;* but we have no instance where the proportions are as 23 to 28.

Each simple substance has a particular proportion in which it combines with a corresponding proportion of other substances. Thus, if we affix to hydrogen the number 1, oxigen 8, carbon 6, iodine 124, &c., any two of these bodies will combine, in the proportions, by weight, of the numbers affixed; or of multiples of them. Thus water is composed of hydrogen 1, and oxigen 8: hydriodic acid of hydrogen 1, and iodine 124, &c. The number belonging to each substance, shewing the proportion in which it combines, is called its *equivalent.* Primary compounds, when they combine again to form secondary compounds, observe the same law; and *their* equivalents are the numbers produced by adding together the equivalents of their component elements. Thus the equivalent of water is 9. It will therefore be seen that the neutralizing power of any substance is *greater,* in proportion as its equivalent number is *smaller.* For the most part, though not always, those bodies have the most energetic general power of combination, or force of chemical attraction, which have the smallest equivalent numbers; as hydrogen, carbon, oxigen, &c., and among the metals, potassium, of which the number is 40, sodium, 24, barium, 70, iron, 28, compared with mercury, 200, silver, 110, gold, 200, &c.

A remarkable fact was established some years ago, by M. Gay Lussac, an eminent French chemist. Gases and vapours unite together, by volume or measure, in very simple proportions; and their specific gravities appear to correspond with their equivalent numbers. Thus one measure or volume of oxigen gas combines with *exactly* two of hydrogen, to form water. Sulphurous acid may be formed by combining together *exactly* equal volumes of oxigen and of the vapour of sulphur. Oxigen is lighter than sulphurous acid gas, in the proportion of 8 to 16; numbers which *exactly* correspond with their equivalents.

From the preceding doctrines it results, that supposing the equivalent numbers to be correct, when the composition of a body has been approximatively ascertained, the exact proportion of its elements may be *inferred* by calculation of their equivalents; and these inferences may be relied on with some confidence, where the evidence of accurate experiment is unattainable. At least, the accuracy of an analysis is corroborated by its close correspondence with such inference.

Equivalents of some of the principal substances.

Hydrogen	1
Oxigen	8
Water (H 1 + O 1)*	9
Nitrogen	14
Ammonia (N 1 + H 3)	17
Protoxide (N 1 + O 1)	22
Deutoxide (N 1 + O 2)	30
Nitric Acid (N 1 + O 5)	54
Carbon	6
Carbonic Oxide (C 1 + O 1)	14
——— Acid (C 1 + O 2)	22
Sulphur	16
Sulphurous Acid (O 2 + S 1)	32
Sulphuric (O 3 + S 2)	40
———Liquid (Water, 1)	49
Sulphuretted Hydrogen (S 1 + H 1)	17
Phosphorus	15
Chlorine	36
Muriatic Acid (C 1 + H 1)	73
Bromine	75
Iodine	124
Potassium	40
Sodium	24
Barium	70
Strontium	44
Calcium	20
Magnesium	12
Iron	28
Protoxide (I 1 + O 1)	36
Peroxide (I 1 + O1½)	40
Zinc	34
Tin	58
Arsenic	38
Antimony	44
Lead	104
Protoxide (L 1 + O 1)	112
Sesquioxide (L 1 + O 1½)	116
Peroxide (L 1 + O 2)	120
Mercury	200
Protoxide (M 1 + O 1)	208
Peroxide (M 1 + O 2)	216
Protochloride (M 1+ C 1)	236
Perchloride (M 1 + C 2)	272
Silver	110
Gold	200
Platinum	96

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* (H 1 + O 1) is a concise mode of expressing that one equivalent of hydrogen (H) combines with (+) one equivalent of oxigen (O) to form the compound named.

ISOMERIC COMPOUNDS.

Of late years it has been established as a fact, that two compounds may be precisely similar in the nature and proportions of their elements; and yet be essentially different from each other in their properties. Such compounds are said to be *isomeric;* and many isomeric substances at present known. Thus phosphoric acid, and pyrophosphoric acid have precisely the same composition as far as we can ascertain; yet where they combine with bases, the resulting salts present marked characteristic differences from one another. By a little calculation, the student will readily perceive, that water saturated with protoxide of nitrogen must be isomeric with a solution of nitrate of ammonia in a certain state of dilution.

SPECIFIC GRAVITY.

By *specific gravity* is meant, the weight of any given bulk of a substance, compared with the same bulk of a common standard. For the specific gravity of liquids and solids, distilled water is the standard: for that of gases and vapours, common air. Thus, if a bottle be so adjusted as to contain, when filled, exactly 1000 grains of water, it will hold 1840 grains of sulphuric acid, and only 820 of alchohol. The specific gravity of sulphuric acid is therefore said to be 1·840, that of alcohol 0·820. The specific gravity of solids, as the fixity of their form precludes the possibility of taking their dimensions in the same manner, is usually ascertained by weighing them first in air, and then in water, by means of a hydrostatic balance, if the substance be heavier than water, and not soluble in it.

Suppose a piece of metal to weigh 100 grains in the air, and 50 grains under water, then, on subtracting the weight under water from the weight in the air, and dividing the weight in the air by the remainder, the quotient will give 2·0, which is the specific gravity required.

Gases are weighed in a thin globe of glass, to which a stopcock is attached. This is first exhausted by means of an air-pump, or exhausting syringe, weighed in this state, again after admitting the air, and finally when filled with the gas under experiment. By comparison of the weights, the specific gravity of the gas is estimated. Several precautions are necessary in performing with any degree of accuracy these delicate experiments, but it would be unsuitable to detail them here. One pint of common air weighs about 9 grains; hydrogen is fifteen times lighter; chlorine more than twice as heavy; and hydriodic acid gas is more than four times as heavy.

FINIS.

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CHEMICAL APPARATUS,

OF THE BEST DESCRIPTION,

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DAVY & CO., OPERATIVE CHEMISTS,

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FURNACES, CRUCIBLES, &c.

Portable Furnace, on the principle of Dr. Black.—This useful furnace is made of strong sheet iron, lined with fire-clay to confine the heat. It is very durable; and may be used in a room with safety. By closing or opening the door of the ash-pit, and shortening or lengthening the height of the chimney, any degree, from a low red to a strong white heat, may be commanded. It may be used for crucible operations; assays by cupellation; evaporations, and distillations, either by the naked fire, or by the sand bath; and for igniting tubes. *Round*, 8*inch. diam. inside*, £3. 10*s.*; *oval*, 10*inch. diam.*, £5. 5*s. to* £6. 6*s.*

Several modifications of these furnaces at various prices; that represented in *Fig.* 1. of the Plate is preferred on the Continent to all others; and it possesses some evident advantages over the ordinary construction, £1. 16*s. to* £8. 8*s.*; *and intermediate prices*, *with or without the dome top*, *sand baths*, *&c.*

Black Lead Furnaces, of several forms and dimensions, 14*s.*, £1. 2*s.* 6*d.*, and £1. 12*s.* These, on account of their cheapness, are much in use as substitutes for the more lasting and serviceable furnaces last described.

Aikin's Portable Blast Furnace, 14*s.* to £3. 3*s.* With this furnace, by means of a pair of double bellows, a very intense heat may be rapidly raised. It is capable of fusing cast-iron, cobalt, &c.

Blast Furnace, *described in Dr. Faraday's work on Chemical Manipulation.* This appears to possess some advantage in power over the preceding. Even platinum has occasionally been fused in it.

Chauffers, for moderate heats with charcoal, 10*s.* 6*d.* to 15*s.*

Double Bellows, £1. 5*s.* to £2. 10*s.* These differ from common bellows, in producing an uninterrupted and continuous blast of air.

Hessian and Cornish Crucibles, *triangular and scuttle shaped; single 2d. to* 1*s. each ; the former in nests,* 9*d. and* 1*s.* These crucibles are more infusible by intense heat than any other, and resist the action of fluxes.

Black Lead Crucibles, 3*d.* to 8*s.* These possess advantages in many cases from their little liability to crack by sudden changes of temperature. Other crucibles, as those of porcelain and platinum, may be enclosed in them for security.

Porcelain and Wedgewood Crucibles, 3*d.* to 3*s.* Much neater than the common crucibles ; but too liable to crack for general use. The smaller ones are occasionally employed in delicate operations, where vessels of platinum would be inadmissible.

Crucibles of German and French Porcelain. These are very neat ; and, the former especially, appear to possess considerable superiority over the ordinary Wedgewood.

Platina Crucibles, *per oz.* 34*s. if not very small ; or from* 7*s. each upwards.* The most useful of all crucibles in experimental chemistry. They never crack ; are perfectly infusible in common furnaces ; and resist the action of the simple acids and most fluxes. They may be heated over a powerful spirit lamp, (See *Fig.* 9.) or if in the furnace, should be enclosed in a crucible of black lead. They must not be used in any experiment with nitromuriatic acid ; nor where chlorine is likely to be evolved ; nor with pure potass ; nor in any case where it is probable a metal will be reduced. If, for example, black flux and oxide of lead were fused together in one of them, the reduced lead would alloy with the platinum and melt it into holes. They are best cleaned with silver sand.

Crucible Tongs. Platina crucible forceps, 5*s.*

Sand Baths, 8*s.* to 30*s.*

CHEMICAL LAMPS.

ARGAND OIL LAMPS, 7*s.* 6*d.* to £1. 1*s.* *(Fig.* 3). Sometimes called *Lamp Furnaces.* These produce a very steady and easily regulated heat, sufficient for solutions, evaporations, distillations, &c., on a small scale. The more expensive have a *double* concentric wick, by which contrivance, they are capable of producing considerably more heat. The best sperm oil should be burnt in them.

SPIRIT LAMPS, *with ground glass caps,* 4*s.* 6*d. and* 5*s.* *(Frontis. fig.* 3, *a.)* *Ditto small, with brass caps,* 2*s.* 6*d.* *(Fig.* 4, *f.)* The combustion of spirits of wine produces great heat, without smoking the vessels exposed to its flame. The cap prevents the evaporation of the spirit when the lamp is not in use. *Pyroligneous æther,* sometimes called wood naptha, or pyroxylic spirit, is an economical substitute for spirits of wine. Small glass tube may easily be bent over the spirit lamp.

SPIRIT LAMP, *with cylindrical wick, on the principle of Berzelius, with subsequent improvements,* 10*s.* 6*d.* to 16*s.*; with stand, &c. *(Fig.* 9*)*, £1. 1*s.* to £1. 11*s.* 6*d.* This very convenient lamp is applicable to all the purposes of the argand oil lamp, and is besides capable of producing far higher degrees of heat. It may often supersede the use of a furnace, as it can heat a platinum crucible of moderate size to bright redness, and effect the fusion of carbonated alkalis for the analysis of silicious minerals.

BLOWPIPE & MINERALOGICAL APPARATUS.

WOLLASTON'S POCKET BLOWPIPE *(Fig.* 5*)*, 6*s.* 6*d.* The most portable of all blowpipes for the pocket: when taken to pieces, it packs into the size of a common pencil case.

PEPYS'S BLOWPIPE, *(Fig.* 4*)*, 6*s.* 6*d.*; GAHN'S DITTO, 7*s.*; BERGMAN'S, 5*s.*; BLACK'S, 3*s.* 6*d.* All these have a contrivance to collect the condensed moisture from the breath, which is otherwise apt to cause annoyance, by spirting through the jet of the instrument in prolonged experiments.

PLATINUM JETS, 2*s.* *to* 3*s.* 6*d.* When these become stopped up, they may be heated to redness on a piece of charcoal in the blowpipe flame, which will burn out the obstruction without risk of enlarging the aperture, which there would be in using a needle.

COMMON BLOWPIPES, 9*d.*; GLASS DITTO WITH BULBS, 1*s.*

BLOWPIPE TABLE, WITH DOUBLE BELLOWS, *to be worked by the foot*, £4. 4*s.* to £6. 6*s.* This is the most powerful kind of blowpipe; and is used in forming the smaller articles of glass apparatus out of tubes, by bending, sealing their ends, blowing bulbs, &c.

DAVY'S BLOWPIPE, *for working glass tube, with lamp, on a stand.* This blowpipe is capable of being fixed in any position, so as to leave both hands at liberty, 14*s.* to 21*s.*

HYDRAULIC BLOWPIPE, £2. 12*s.* 6*d.* This is a contrivance for rendering the blast of air continuous, though supplied from the mouth only at intervals. It is convenient in working glass tube.

BLOWPIPE SPOONS OF PLATINA, *with or without ivory handles*, 2*s.* to 7*s.* 6*d.*

BLOWPIPE FORCEPS, *with platinum tips*, 6*s.* *Hauy's double ditto*, 7*s.* 6*d.*

PEPYS'S DITTO, *with cupped tips*, 7*s.*, 8*s.* Very useful for holding in the flame substances which decrepitate by heat.

PLATINA FOIL AND WIRE, per oz. 22*s.* Very fine wire, higher.

ALDER CHARCOAL, per oz. 6*d.*

ENAMELLERS' BLOWPIPE LAMP, 5*s.*, 7*s.* 6*d.*

BERZELIUS'S PORTABLE BLOWPIPE LAMP 12*s.*, 15*s.* The lamp may be raised to any height by means of a screw and socket sliding upon a brass rod, which fixes into a foot. When taken to pieces, it packs into a very small compass, and may be carried in the pocket; as there is no risk of spilling a drop of oil.

MAGNIFIERS, for examining minute blowpipe products, &c., 3*s.* to 7*s.* 6*d.*

MINERALOGICAL HAMMERS, 3*s.* to 8*s.*

DITTO ANVILS, 2*s.* to 7*s.* 6*d.*

FOR PULVERIZATION, SOLUTION, EVAPORATION, PRECIPITATION, TESTING. &c.

MORTARS WITH PESTLES of Wedgewood ware, No. 1, 1*s.* 6*d.*; 2, 1*s.* 10*d.*; 3, 2*s.* 3*d.*; 4, 3*s.*; 5, 5*s.*; 6, 7*s.*; These answer well for common purposes of pulverization.

DITTO OF PARISIAN AND GERMAN PORCELAIN, a varied assortment. Some of these are much harder than those of Wedgewood.

IRON MORTARS, for rough purposes.

AGATE MORTARS, 7*s.* 6*d.* upwards. Their extreme hardness renders them indispensable in pulverizing minerals for exact analysis. A very small one is required to pulverize substances for blowpipe experiments.

STEEL MORTARS, 7*s.* to 14*s.* For crushing rich gems, or other hard substances, into small fragments, to be afterwards finely pulverized in mortars of agate.

FLASKS AND MATRASSES, 4*d.* to 2*s.* *(Frontis. fig.* 3, *c.)* FLORENCE FLASKS, 4*d.*, 8*d.* The bottoms of these are of very thin glass, and well calculated to bear the application of heat.

CAPSULES, OR EVAPORATING BASINS, of Wedgewood ware, in nests or single, No. 1, 3*d.;* 2, 4*d.;* 3, 5*d.;* 4, 6*d.;* 5, 7*d.;* 6, 9*d.;* 7, 11*d.;* 8, 1*s.* 1*d.*; 9, 1*s.* 4*d.;* 10, 1*s.* 6*d;* 11, 1*s.* 9*d.;* 12, 2*s.;* 13, 3*s.* 3*d.*

Ditto of superior quality, from 1½ *to double the foregoing prices.* These are more perfectly glazed and less liable to crack by moderate changes of temperature.

Capsules of Paris and German Porcelain, 1*s.* to 15*s.* The superiority of these consists in their being little liable to crack by sudden changes of temperature; and their glaze is less easily attacked or penetrated by chemical agents.

WATCH GLASSES, 3*s.* to 4*s.* *per doz.* Very convenient for evaporations on a minute scale.

CAPSULES OF PLATINA, 32*s.* to 36*s.* *per oz.* Evaporating vessels of this valuable metal are by far the best of any; those of very large size are precluded from general use by nothing but their expense.

PLATINA SPATULAS, 12*s.* to 25*s.*

STEEL DITTO, 1*s.* 6*d.* to 5*s.*

DITTO OF IVORY, BONE, AND WOOD.

GLASS RODS, 4*d.* to 2*s.* For stirring corrosive liquids.

PRECIPITATING AND LIPPED ALE GLASSES, 1*s.* to 3*s.* 6*d.* The form of these is favourable to the ready subsidence of precipitates.

FUNNELS OF GLASS, 6*d.* to 2*s.* 6*d.*

DITTO OF WEDGEWOOD, 9*d.* upwards.

FILTERING PAPER, *per quire*, 2s. *upwards.*

DITTO, *of very superior quality for analyses,* *per quire.*

SYPHONS, 1*s.* to 5*s.*

DROPPING TUBES, 1*s.* DROPPING BOTTLES 2*s.* to

3*s.* 6*d.* These are contrivances for allowing water, or any other liquid to pass in drops, or in a slender forcible jet; which is very convenient in many cases; as in collecting precipitates, &c.

PRECIPITATING RODS OR PLATES, *of various metals. Zinc,* 2*d. to* 9*d. each. Tin, Iron, Copper,* 6*d. to* 2*s. each.*

TEST PAPERS, *Litmus, Turmeric, and Brazil Wood,* 1*s. per doz.*

TEST TUBES, 3*s.* to 6*s.* per doz.

RACKS *for the same,* 1*s. to* 2*s.* 6*d.*

HOLDER *for supporting a test tube when hot.*

DITTO *for a watch glass.*

FOR DISTILLATION

GLASS RETORTS, *plain, from* 2 *oz. to* 1 *quart capacity (Fig.* 12*),* 10*d. upwards.* Glass retorts are in continual requisition for distillations and for procuring gases, (See *page* 14).

DITTO TUBULATED *(Frontis. fig.* 2, *g.),* 2*s. upwards.* The aperture (*h.*) over the body of the retort, which is fitted with a glass stopper, renders more convenient the introduction of the substance to be acted upon.

RECEIVERS, *plain,* 9*d.* upwards.

DITTO *tubulated (Fig.* 13*),* 2*s. upwards.* Where an uncondensable gas is generated during the distillation, either the stopper of this receiver may be removed when necessary to allow its escape, or a bored cork containing a bent glass tube, may be inserted, and the gas collected in the usual way.

DITTO QUILLED (See *page* 15), 1*s.* 6*d.* upwards.

RETORTS OF GREEN GLASS, 1*s.* 3*d. upwards.* Green glass (having either no lead, or very little in its composition), is less fusible than common flint glass. Small retorts of this description are therefore preferable for exposure to a temperature approaching a low red heat, as in the preparation of oxigen gas from chlorate of potass.

RETORTS OF EARTHENWARE AND FINE PORCELAIN, 1*s.* 6*d. upwards.* Used for distillations at a red or white heat, as in the preparation of phosphorus.

SMALL LEADEN APPARATUS FOR THE DISTILLATION OF FLUORIC ACID, *on the plan of Dr. Reid,* £1. 1*s.*

TIN STILLS, which may be used on a common fire, £1. 1s.

STILLS *with worm tubs, complete,* of any size to order.

ITALIAN RECIPIENTS, *for separating essential oils from the water after distillation.*

Glass Alembics, 5*s.* to 12*s.* Occasionally convenient for sublimations, &c.

FOR PNEUMATIC CHEMISTRY.

Pneumatic Troughs *(Frontis. fig.* 2, *a.)* 5*s. to* £1. 1*s.* (See *page* 22*)*.

Davy's improved Mercurial Trough *of japanned cast iron (Fig.* 17*)*, 10*s.* 6*d.* The great desideratum in this apparatus is, that it should preserve as great a surface as possible for experiments, and yet require as little mercury as possible to fill it. From 22lb. to 28lb. are sufficient.

Davy's improved Gahn's Holder *(Fig.* 18, *a. b.* and 17, *a. a.)*, 15*s.* A most convenient appendage to the mercurial trough, enabling us to fix the air jars steadily in any desired position.

Mercurial Trough, *with Holder, on a tray to catch any mercury that may be spilt, and with a cover to keep off dust, when not in use, complete,* £2. 2*s. to* £3. 13*s.* 6*d.*

Air Jars, plain, single, or nested, each 1*s.* upwards, *(Frontis. fig.* 3, *d.)*

Ditto stoppered, or capped, *(Frontis. fig.* 2, *b.)* 2*s.* 6*d. upwards.*

Small Mercurial Trough, of solid hard mahogany, requiring only 6lbs. or 8lbs. of mercury. Air jars for ditto, 9*d.* to 1*s.* 6*d.* each.

Stopcocks *(Frontis. fig.* 2, *c.)*, 4*s.*; *small ditto*, 3*s.* 6*d.*

Brass Connectors to join two stopcocks together *(Frontis. fig.* 2, *d.)*, 1*s.* 6*d.*

Bladders, *(Frontis. fig.* 2, *e.) mounted with brass pieces to receive stopcocks*, £2. 2*s.* 6*d.*

Brass Tobaccopipe, 2*s.* 6*d.* (See *Exp.* 87.*)*

Deflagrating Ladle, *of copper*, 9*d.*; *ditto very large*, 1*s.* (See *Exp.* 80*)*.

Iron Bottle, *with flexible tube (Fig.* 15*)*, 12*s. and* 14*s. Ditto small, of wrought iron*, 15*s.* For obtaining certain gases which require the aid of a red heat.

Gas Bottles, *plain*, 4*s. to* 7*s.* 6*d.*; *Tubulated*, 5*s.* 6*d. to* 12*s.* These are furnished with curved glass tubes, fitted air tight by grinding, and are used for obtaining gases.

Ditto, with tubes fitted by bored corks, 1*s.* 6*d.* to 4*s.* 6d.

Jars and Tubes, *graduated in cubic inches, tenths, and hundredths, for measuring gases*, 3*s. to* 10*s.* 6*d.*

Pepys's Gas Holder *(Fig.* 16, *a. b. c.)*, £1. 11*s.* 6*d.* £2. 2*s.* and £3. 3*s.* The most convenient means of storing considerable quantities of such gases as are used largely in experiments, as oxigen, &c.

Oxyhydrogen Blowpipe *(Frontispiece, fig.* 1*)*, *complete*, £2. 11*s.* 6*d.* and £3. 3*s.* This consists of a small bladder (*a.*), from which the mixed gases are expelled by the pressure of the flat board (*b.*) against another board (*c.*), from a weight, or the hand acting at (*d.*) This bladder, communicating with a pipe which lies under the board (*c.*), but is not seen in the plate, the gases issue through the stopcock (*e.*) and the safety jet (*f.*), and are inflamed at (*g.*), where a metallic rod is represented as ignited by their combustion. When the bladder (*a*) is exhausted, a fresh supply of gas is admitted from the bladder (*h.*)

Hemming's Safety Jets *(Frontis. fig.* 1, *f.)*, 8*s.* 6*d.* 12*s.* This is a tube containing very carefully and closely packed bundles of fine wire; between the interstices of which the gas passes. The retrograde combustion of the gas is thus intercepted, on the principle explained under *Exp.* 107.

Oxyhydrogen Blowpipe, *with two concentric jets (Fig.* 37*)*. In this contrivance, the two gases proceeding from separate reservoirs are made to mix perfectly at their exit, and produce a powerful effect, without even the idea of danger from explosion. Jets, 9*s.*, 10*s.* 6*d.* Apparatus, complete, £1. 1*s.* to £3. 3*s.*

Air Pumps, £1. 10*s.* to £21.

Exhausting Syringes, 7*s.* 6*d.* to 12*s.*; **Condensing ditto**, 9*s.* to 15*s.*; *Syringe, which both exhausts and condenses*, 16*s.* to 25*s.*

Flask for weighing Gases, 3*s* 6*d.*; ditto with stopcock, 7*s.* 6*d.*

Eudiometers, Hope's, or Henry's, 10*s.* 6*d.*, 12*s.*

Ditto Ure's *(Fig.* 22), 8*s.* 6*d.*, 10*s.* 6*d.* The most convenient instrument for analysing gases by means of the electric spark.

Hydrostatic Funnels, 2*s.* 6*d.*

STANDS AND SUPPORTS.

Brass Stand with Sliding Rings, capable of being adjusted and fixed at any height by means of screws *(Frontis. fig.* 3, *b.)* No. 1, 7*s.* 6*d.*; 2, 10*s.* 6*d.*; 3, 16*s.*

Gay Lussac's Holder *(Fig. 11)*, 7*s*. A useful appendage to the ring stand, being a contrivance for fixing tubes, small retorts, &c., at any height, and at any degree of inclination.

Large Iron Stands, *on the same principle as those of brass, but of cheaper construction*, 6*s*. *to* 12*s*.

Small Wire Stands, 2*s*.; with adjusting screws, 3*s*. 6*d*.

Listed Rings, or *Hoops for supporting Flasks*, 6*d*. *to* 1*s*.

Blocks *of different heights*, *per set*, 5*s*. These are of constant use in the adjustment of apparatus.

Supports of various kinds, made of wood.

FOR EXPERIMENTS ON HEAT AND COLD, METEOROLOGICAL APPARATUS, &c.

Mercurial Thermometers, 4*s*. 6*d*. upwards.

Pocket ditto, 6*s*. upwards.

Ditto with very neat ivory scale, *in a case*, 15*s*.

Chemical ditto *with hinge scale*, 10*s*. 6*d*. to 16*s*. By this contrivance the bulb may be left exposed when required to be immersed in liquids. The instrument at 16*s*. ranges to the boiling point of mercury.

Spirit Thermometers, for very low temperatures.

Register Thermometer, £1. 1*s*. This instrument has two bulbs and stems, with an index in each, from which the observer can learn the highest and lowest points which the thermometer may have reached during his absence.

Barometers, *common, or very accurate for chemical observations*, £2. 12*s*. 6*d*. *to* £5. 5*s*.

Daniel's Hygrometer, £2. 12*s*. 6*d*. An elegant instrument for ascertaining with precision the degree of moisture existing in the air.

Freezing Apparatus.

Wollaston's Cryophorus, 5*s*. This is an instrument to demonstrate the rapidity of evaporation under diminished pressure, and the cold thereby produced. It consists of a bent glass tube, having a bulb at each end, and hermetically sealed. It is exhausted of air, but contains a little water. On immersing the empty bulb in a freezing mixture, the condensation of the vapour forms a copious deposition resembling frost; while such rapid evaporation is produced from the water in the other bulb as to freeze it in a short time.

ELECTRICITY AND GALVANISM.

Electrical Machines, £2. 2*s*. to £21.
Ditto packed in boxes with various apparatus, complete, £7. 7s. to £25.
Galvanic Batteries *Cruikshanks's construction, with* 50 *pairs of plates ¾inch. square, fixed in a wooden trough,* £1. 8*s*. *Ditto* 2¼*inch. square*, £1. 16. *Ditto* 3*inch.* £2. 14*s*. *Ditto* 4*inch.* £3. 8*s*.
Galvanic Battery in porcelain trough, with double copper plates (Wollaston's) 12 plates, 4inches square, £2. 7*s*. 6*d*.

FOR WEIGHING.

Common Scales and Weights, 5*s*. and upwards.
Balance, *on a brass pillar, accurately adjusted for chemical purposes, with or without weights,* £2. 2*s*. upwards.
Ditto *of very superior manufacture, in a glass lantern case,* £6. 6*s*. *to* £21.
Decimal Weights, in sets from 100grs. to $\frac{1}{10}$gr. 18*s*.
Ditto *from* 1000gr. *to* $\frac{1}{100}$ gr. £1. 10*s*. to £2. 2*s*. These weights are examined with scrutinising care to ensure accuracy.
Hydrostatic Balances, *packed in mahogany case, with appendages complete,* £4. 4*s*. to £7. 7*s*.
Specific Gravity Bottles, 5*s*. to 15*s*.

CHEMICAL TUBE APPARATUS.

With which an extensive series of experiments on a small scale may be economically performed. *In sets* £1. 1*s*. to £5. 5*s*.*; or singly as follows.*
Tube Retorts *(Fig.* 29, *a.)* 6*d*. 8*d*., *and Receivers (b.)* 4*d*.
Faraday's cohobating Tube *(Fig.* 30*)*, 1*s*. 6*d*.
Tube Funnels, 6*d*. to 1*s*.
Recipient Tube, for operating where both a liquid and a gas are disengaged *(Fig.* 40*)*, 1*s*. 6*d*. *to* 2*s*. 6*d*.
Cooper's Tube *(Fig.* 41*)*, 1*s*. 6*d*. to 2*s*. 6*d*. For collecting gases, whether absorbed by water or not.
Desiccating Tube, 2*s*. 6*d*. to 5*s*., containing chloride of calcium for drying gases, *(page* 44*)*.

Tube for heating solids in gases *(Fig.* 33*)*, of very infusible glass. The *Figs.* 31, 32, and 33, represent the arrangement of the two last tubes for reducing a metallic oxide, by heating it in dry hydrogen gas.

DAVY'S TUBE, for passing a gas through a liquid *(Fig.* 35, See *page* 26,) 3*s.* 6*d.* to 5*s.*

BERZELIUS' ARSENIC TUBE, *(Fig.* 28, See *Exp.* 50*)*, 6*d.*

Tubes sealed at one end, with or without bulbs, and some of green glass for strong heats, 3*d.* to 1*s.*

MISCELLANEOUS.

Scales of Equivalents, 7*s.* 6*d.* to £1. 1*s.*

Flint Glass Tube, per lb. 2*s.* 6*d.*; small, 4*s.*

Tube of Glass made without lead, per lb. 4*s.* to 5*s.* 6*d.*; Green (wine bottle) Glass Tubes, very infusible, 6*d.* per oz.

Tubes of Iron, Porcelain, and Earthenware, 1*s.* to 10*s.* 6*d.*

Caoutchouc connecting Tubes, 3*d.* to 6*d.*

Caoutchouc flexible Tube in lengths, 2*s.* to 3*s.* 6*d.* per foot.

Liquid Caoutchouc, per pot, 2*s.* 6*d.*

ASSORTMENTS OF APPARATUS.

For a general course of Experiments in Chemistry, on various scales; intended to assist purchasers in forming their selections of such articles as will be most useful, according to the expense they are willing to incur.

No. 1, *at* £5.

Argand Lamp, Iron Stand with Sliding Rings, one plain and one tubulated Glass Retorts, one Receiver, three Flasks; three Evaporating Basins, four Watch Glasses, Pneumatic Trough, Gas Bottle, two plain Air Jars, one Transfer ditto, one stoppered ditto, one Deflagrating Ladle, Mounted Bladder and Stopcock, Brass Tobacco-pipe, Glass Measure, Dropping Tube, Blowpipe, Platina Foil and Wire, six Test Tubes and Rack, two Stirring Rods, Glass Tube and Caoutchouc Connectors, Pestle and Mortar, Spirit Lamp, Precipitating Glass, Funnel, a Turkey's Crop, and some Tube Apparatus.

No. 2, *at* £10.

All the apparatus in the foregoing list, with the following additions or substitutions.

Larger Argand Lamp, or a Berzelius's Lamp, Brass Ring Stand, one small Wire ditto, additional and larger Glass Retorts, two Funnels, two Florence Flasks, two Stopcocks and a Connector, Blowpipe Jet for Stopcock, a Whirl, Iron Bottle with flexible Tube, superior Gas Bottle and Pneumatic Trough, additional Air Jars, a Graduated cubic inch Tube, Hinge Back Thermometer, additional Glass Tube and Tube Apparatus, Evaporating Basins and Watch Glasses, superior Pestle and Mortar, Blowpipe and Spirit Lamp, Files, and Oxyhydrogen Blowpipe.

No. 3, *at* £15.

The foregoing apparatus, some of them on a larger scale, or of superior quality with the following additions.

Black Lead Furnace, and a set of Crucibles, Box of Scales and Weights, Platina Capsule, small Mahogany Mercurial Trough, and Jars to correspond, Electrophorus, Ures' Eudiometer.

No. 4, *at* £20.

The foregoing apparatus with the following additions, Pepys's Gas Holder, Blowpipe for working glass tubes, Scale of Equivalents, Platina Crucible, Hope's Eudiometer, Steam Bath for drying precipitates, larger Furnace, several of the apparatus larger, or in additional number.

No. 5, *at* £30.

The foregoing, with a further supply of Retorts, Flasks, Crucibles, Air Jars, &c., larger Platina Crucible and Capsule, Chest containing twenty-four bottles of the most useful Tests, a set of Precipitating Rods, a superior Furnace, Pocket case of Mineralogical Apparatus, Flask for weighing Gases, Hydrostatic Balance, Syphon, Aikin's Blast Furnace and Double Bellows, an Alembic and a Leyden Vial.

From £50. *to* £150.

A room fitted up for the purpose of a Laboratory on a more or less extensive scale.

CHESTS.

DAVY'S CHEMICAL CHESTS, containing assortments of Apparatus and Chemicals for a general course of Chemical study or amusement, and sufficient for the performance of a part, or the whole of the experiments in this work. Those cheap articles which can be purchased of any druggist are omitted in the chests, as unnecessarily encumbering them.

No. 1,—14*s.* 6*d.*; 2, £1. 10*s.*; 3, £2. 6*s.* *(Frontis. fig. 4)*; 4, £6. 6*s.*; 5, £25.

The smaller chests may be obtained of some of the Chemists in almost every principal town in the kingdom. The others will be promptly forwarded to order.

Chests containing the requisites for the Analysis of Poisons, with specimens, &c., corresponding generally with Dr. Christison's work on this subject, £2. 12*s.* 6*d.* to £12. 12*s.*

Medico Chemical Chests, containing the requisites for a course of Experiments on the Chemistry of the Pharmacopœia; designed for the Use of Students preparing for Apothecaries' Hall, who may desire to impress the theories of the various processes on their minds, by *Chemical demonstrations.*

Mineralogical Travelling Chests, on the plan of Berzelius and others, £3. 3*s.* to £8. 8*s.*

Mineralogical Pocket Case, containing the Blowpipe and its most necessary appendages, £1. 1*s.* to £2, 2*s.*

Test Chests, with or without apparatus for general Analysis, £2. 2*s.* upwards.

Minerals, single, or in collections of 100 or more, illustrative of Mineralogy and Geology, from £2. 2*s.* upwards.

Cabinet Collections of Drugs, &c., contrasting those which are genuine and good with the inferior samples.

TESTS,

AND OTHER CHEMICAL PREPARATIONS.

S. affixed to any article in this list, signifies it to be in a state of solution. D. dried, or anhydrous. P. chemically pure. N.P. nearly pure. C. common, or in the ordinary state in which the article is met with in commerce. N. native. Cr. in crystals, or so concentrated as to be in a crystalizable state. *All* the preparations employed as tests, and most of the others not specified, are *absolutely pure.*

	s.	*d.*
ACID Acetic . per oz. .	0	3
—— Ditto Cr. ,, .	1	6
—— Arsenic . ,, .	1	0
—— Arsenious ,, .	0	2
—— Benzoic . ,, .	3	6
—— Boracic . ,, .	1	0
—— Camphoric ,, .	15	0
—— Chloric . ,, .	6	0
—— Chromic		
—— Citric . . ,, .	1	0
—— Fluoboric, S. ,, 1*s*. &	2	0
—— Fluoric . ,, .	0	6
—— Fluosil, S. ,, 6*d*. &	2	0
—— Gallic . . ,, .	12	0
—— Hydriodic ,, 1*s*. 6*d* &	2	6
—— Hydrocyanic ,, 2*s*. to	6	0
—— Hyposulph. ,, .	7	0
—— Iodic . . per dr. .	3	6
—— Lactic		
—— Malic		
—— Meconic		
—— Molybdic		
—— Muriatic, P. per oz. .	0	2
—— Ditto, C. . per lb. .	0	4
—— Nitric, P. per oz. .	0	3
—— Ditto, C. per lb. .	2	0
—— Nitrous . ,, .	1	6
—— Do. Anhydr. per oz. .	6	0
—— Oxalic . ,, .	0	4
—— Ditto, P. ,,	0	6
—— Perchloric ,, .	16	0
—— Phosph. Vit. P. .	14	0
—— Ditto, N P ,, .	3	0
—— Ditto, S. ,, .	1	6
—— Pyrolign per oz. .	0	4
—— Succinic ,, .	9	0

	s.	*d.*
ACID Sulphuric, P. per oz	0	4
—— Ditto, C. per lb. .	0	6
—— Do. fuming per oz. .	0	6
—— Do. do. Cr. ,, .	2	6
—— Do. Anhydr. ,, .	8	0
—— Sulphurous, P. per dr.	2	0
—— Do. S. . per oz. .	0	6
—— Tartaric . ,, .	0	6
—— Tungstic . ,, .	12	0
Alcohol, Absol. ,, .	0	8
———— Sp. gr. per lb. .	4	0
Æther Acetic . per oz. .	1	0
——— Muriatic ,, .	1	0
——— Nitric . ,, .	0	9
——— Sulph. rect. ,, .	0	9
——— Pyrolign. per lb. .	1	6
Alum . . . . per oz. .	0	1
Alumina . . . 1*s*. 6*d*. to	5	0
——— Acet. S. ,, .	0	6
——— Mur. S. ,, .	0	6
Aluminum . . per gr. .	2	0
——— Chloride per dr. .	5	0
Ammonia, S. per oz. 2*d*. 3*d* & 8*d*.		
——— Benz. . per oz. .	4	0
——— Carb. . ,, .	0	2
——— Fluate ,, .	2	0
——— Hydros. S. ,, .	0	6
——— Do. Cr. per specimen	5	0
——— Muriate per oz. .	0	2
——— Do. P. . ,, .	0	6
——— Nitrate . ,, .	0	4
——— Oxalate ,, .	1	0
——— Phosph. ,, .	1	0
——— Succin. S ,, .	0	6
——— Sulph. . ,, .	0	3
Antimony. P. ,, .	1	6

	s.	*d.*
Antimony, C. per oz.	0	3
—— Oxide . ,,	1	0
—— Sulphur. per lb.	1	0
Arsenic . . . per oz.	0	4
—— Sulphurets ,,	0	6
Asbestos . . . ,, 6*d.* to	1	6
Baryta . . . ,,	2	6
—— Acetate . ,,	1	0
—— Bromate . per dr.	3	6
—— Carbon, P. per oz.	0	6
—————— N. per lb.	0	8
—— Chlorate . per oz.	6	0
—— Muriate . ,,	0	6
—— Nitrate . ,,	0	8
—— Sulphate N. per lb.	0	6
Barytic Water . per oz.	0	6
Bismuth, P. . ,,	1	6
———— C. . ,,	0	3
—— Oxide . . ,,	1	0
Borax . . . ,,	0	3
Boron . . . . per gr.	1	6
Bromine . . . per dr.	2	6
Cadmium, P. . ,,	3	0
———— N. P per oz.	14	0
———— Carbon. ,,	20	0
———— Oxide. ,,	26	0
Calomel . . . ,,	0	6
Carbon Chlorides per specimen . . ,,	3	6
——— Sulphuret per oz.	4	0
Cerium . . .		
— Oxides per dr. 8*s.* 6*d.* &	10	6
Charcoal, animal per lb.	2	6
——— Powder . ,,	2	0
——— Alder. . per oz.	0	6
——— Box . . ,,	1	0
Chlorine, S. . . ,,	0	3
Chromium . .		
——— Oxide . ,,	1	0
Cobalt, P. . . per dr.	30	0
——— N. P. per oz. 6*s.* to	12	0
——— Acetate, S. ,,	1	6
——— Mur. S. . ,,	1	6
——— Ores . ,, 2s. &	3	0
——— Oxalate . ,,	10	0
——— Oxide . . ,, 8s. &	16	0
Copper, P. . . . ,,		
——— Acetate . ,,	1	0
——— Carbon. ,,	1	0
——— Chloride ,,	1	6
——— Nitrate . ,,	0	8
——— Oxide, red ,, 1s. &	2	6
——— Do. black ,, 1s. &	2	6
——— Sheet . per lb.	2	0
——— Sulphate per oz.	0	2
——— Wire . per lb.	2	0

	s.	*d.*
Distilled Water per gall.	1	0
Ditto very pure per lb.	1	0
Fluor Spar . ,, 6d. &	0	8
Fluxes, black . per oz.		6
——— white . ,,		6
Fulminating Mercury, per oz.	4	0
———— Silver, per dr.	4	6
Fusible Alloy . per oz.	0	6
Glucina . . . per dr.	16	0
Gold, Chloride . ,,	21	0
Iodine . . . . per oz.	2	6
—— Purif. . . ,,	4	0
Iridium, P . . per gr.	1	6
———— N. . per dr.	8	0
Iron, pure . ,,	1	6
—— Acetate . per oz.	0	6
—— Carbonate		
—— Chromate		
—— Ferrocyan, P. ,,	1	0
—— Filings . per lb.	0	6
—— Do. purif. per oz. 2*d* &	0	6
—— Muriate . ,,	0	6
—— Oxide (per) P ,,	0	6
—— Do. prot. P. ,,	2	0
—— Sulphate . ,,	0	2
—— Sulphuret . per lb.	0	8
—— Turnings ,,	0	9
—— Wire . .		
Lead, P. . . . per oz.	1	0
—— Acetate, P. ,,	0	6
—— Ditto C. . ,,	0	2
—— Carbonate ,,	0	3
—— Chromate ,,	0	6
—— Foil . . per lb.	1	6
—— Granul. . ,,	1	6
—— Iodide, Cr. per oz.	3	0
—— Nitrate . ,,	0	8
—— Protox, C. ,,	0	3
—— Ditto, P. . ,,	1	6
—— Sesquioxide ,,	0	3
—— Peroxide . ,,	0	8
Lime, pure . . ,,	2	0
—— Carrara . ,,	0	6
—— Best com. per lb.	0	4
—— Chloride . ,,	1	0
—— Ferrocyan. per oz.	1	6
—— Fluate . . per lb. 6*d.* &	0	8
—— Hydrosulph .S. per oz.	0	6
—— Muriate, Cr. per lb.	5	0
—— Do. fused per oz.	0	6
—— Phosphate, P. ,,	0	4
—— Do. C. per lb.	1	6
—— Phosphuret per oz.	3	6
—— Sulphuret ,,	0	6
—— Water per lb.	0	4

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